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SPAIN

DRAFT OF THE INTEGRATED NATIONAL ENERGY AND CLIMATE PLAN 2021-2030

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Introduction

The energy and climate policy framework in Spain is determined by the European Union (EU) which, in turn, is contingent upon a global context marked by the Paris Agreement reached in 2015, the most ambitious international response to the climate change challenge to date. The Union ratified the Agreement in October 2016, allowing its entry into force in November of that year. Spain ratified it in 2017, thus establishing the starting point for energy policies and climate change in the near future.

Furthermore, in 2016 the European Commission presented its ‘winter package’, *‘Clean energy for all Europeans’* (COM(2016) 860 final), which has been implemented through various regulations and directives. These include reviews of and legislative proposals on energy efficiency[1], renewable energy[2], electricity market design, security of supply and governance rules for the Energy Union[3], with the aim of reducing greenhouse gas emissions, increasing the proportion of renewables in the system and improving energy efficiency in the Union by the 2030 horizon.

This new regulatory and political framework provides regulatory certainty and generates favourable environmental conditions for undertaking the important investments that are needed. It also empowers European consumers to become active players in the energy transition and sets binding targets for the EU by 2030[4]:

- 40 % reduction in greenhouse gas (GHG) emissions compared to 1990;
- 32 % total gross final energy consumption from renewables, for the entire EU;
- 32.5 % improvement in energy efficiency;
- 15 % electricity interconnection between the Member States.

On 28 November 2018 the European Commission updated its roadmap towards a systematic decarbonisation of the economy with the intention of making the **European Union carbon-neutral by 2050**[5].

In addition to responding to this reference framework, the Government of Spain considers that commitment to tackling climate change is a requirement for public policies, not only at state level but also at regional level. Many of the Autonomous Communities have also embarked on ambitious policies concerning climate change. The proactive attitude towards the corresponding energy transition and decarbonisation of the economy is also the best way to position Spain in order to adapt to the unavoidable change that is already happening in the international arena. For this purpose, the predictability of the transformation process must be

[1] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency.

[2] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources.

[3] Regulation (UE) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council.

[4] The objectives of renewable energy, energy efficiency and electricity interconnection may be revised upwards in 2023.

[5] Communication from the Commission, COM/2018/773 final, ‘A clean planet for all. A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy’.

safeguarded in order to ensure that it is aimed towards the preservation of the common good, in particular ensuring the care and protection of the most vulnerable. In other words, it is essential to generate and deploy strategic planning instruments that give a sense of direction, flexibility and manageability to the energy transition and decarbonisation of the economy which we are moving towards, and in this way capture the maximum opportunities for economic development and generation of employment.

Within the abovementioned 'winter package' of the EU, the Governance Regulation establishes the necessary planning procedure to fulfil the objectives and goals of the EU, as well as ensuring the coherence, comparability and transparency of the information presented by the Union and its Member States to the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. In this sense, the EU requires each Member State to prepare an Integrated National Energy and Climate Plan 2021-2030 (INECP), as well as the Long-Term Low Emissions Strategy (2050).

The Draft Integrated National Energy and Climate Plan 2021-2030 presented by each Member State helps the Commission to determine the degree of compliance with the objectives of the Union as a whole. The Governance Regulation defines the structured iterative process between the Commission and the Member States, with the aim of finalising the Plans in 2019 and their subsequent application. This process also includes the need to carry out progress reports every two years.

The Integrated National Energy and Climate Plan 2021-2030 identifies the challenges and opportunities along the five dimensions of the Energy Union: decarbonisation, including renewable energies; energy efficiency; energy security; the internal market for energy; and research, innovation and competitiveness. The Plan also issues the necessary signals to provide certainty and direction to all players.

The INECP is divided into two large blocks. The first provides details about the process, national objectives, policies and existing measures, and measures that are necessary for achieving the objectives of the Plan, as well as analysis of the impact in terms of the economy, employment, distribution and health benefits. The second block comprises the analytical part, which provides details about the projections, both of the Baseline Scenario and the Target Scenario, as well as descriptions of the different models that have made the prospective analysis possible and that give robustness to the results.

Spain presents this Integrated National Energy and Climate Plan 2021-2030 with the objective of advancing in decarbonisation, laying sound foundations to consolidate a path to carbon neutrality of the economy within the 2050 horizon. In this regard, one should remember that in Spain, three of every four tonnes of GHG originate in the energy system, so its decarbonisation is a central element on which the energy transition must take place. In addition, the Plan will be accompanied by the Just Transition Strategy, designed to anticipate and manage with solidarity criteria the consequences on those regions and people directly linked to technologies that will be progressively displaced as a result of the transition promoted by this Plan. On the other hand, given the distribution of powers in Spain, coordination with the Autonomous Communities and the active involvement of such Communities in order to ensure compliance with the objectives of this Plan will be essential.

The execution of this Integrated National Energy and Climate Plan will transform Spain's energy system significantly towards greater energy self-sufficiency based on systematically and efficiently exploiting renewable potential, particularly solar and wind energy. This transformation will have a positive effect on national energy security by making Spain less dependent on imports, the annual economic bill for which is not only very large, but is subject to the geopolitical fluctuations and price volatility of these markets.

In addition, as a result of the execution of the Plan, in 2030 we expect to have achieved 42 % of final energy use from renewables, due to the large investment expected in renewable electric and thermal energy. This also includes a significant reduction in final consumption of energy as a result of savings and efficiency programmes and measures in all sectors of the economy.

Finally, it should be noted that the drive to deploy renewable energies, distributed generation and energy efficiency promoted by this Integrated National Energy and Climate Plan is embedded in the territory. As a result, its execution will generate significant investment and employment opportunities for the regions and districts of the country that currently have higher unemployment rates and lower levels of economic development.

In this regard, the industrial, economic and employment opportunities that are identified in the deployment of this Integrated National Energy and Climate Plan and promoted in those regions and districts most affected by the energy transition and the decarbonisation of the economy will be especially relevant.

1 SYNTHESIS AND DRAFTING PROCESS OF THE INTEGRATED NATIONAL ENERGY AND CLIMATE PLAN

1.1 EXECUTIVE SUMMARY

The measures provided for in the Integrated National Energy and Climate Plan will allow the following results to be achieved in 2030:

- 21 % reduction in greenhouse gas (GHG) emissions compared to 1990;
- 42 % of energy end-use from renewables;
- 39.6 % improvement in energy efficiency;
- 74 % renewable energy in electricity generation.

In 2050 the objective is to achieve climate neutrality, with the reduction of our GHG emissions by at least 90 %, in line with the European Communication, as well as achieving a 100 % renewable electricity system.

Decarbonisation of the economy and progress in renewables

The long-term objective that guides the preparation of the Plan is to **convert Spain into a carbon-neutral country in 2050**, for which it aims to achieve a degree of mitigation of gross total emissions of greenhouse gases (GHG) on that date of 90 % compared to 1990.

To that end, the objective of the Plan is to achieve a reduction in emissions of at least 20 % in 2030 compared to 1990. According to the forecast made by the Plan, the measures provided for in it will achieve a 21 % reduction in emissions. The non-ETS sectors (residential, transport, agriculture, waste, fluorinated gases and industry not subject to emissions trading) will contribute with a mitigation of 38 % in 2030 compared to the levels in 2005, while the sectors subject to emissions trading will contribute with a decrease of 60 % compared to 2005.

We must clarify that the path laid down for achieving the objectives set for 2030 is based on the principles of technological neutrality and cost efficiency. The energy modelling carried out to achieve the objectives of the Integrated National Energy Climate Plan (INECP) takes into account the foreseeable development of the benefits and costs of all technologies over time. It is also based on the premise of the cost-efficient maximisation of the deployment trajectories of the different technologies, while respecting the boundary conditions established with the objective of fulfilling the objectives of the five dimensions of the INECP.[6]

Given that three out of four tonnes of greenhouse gases originate in the energy system, their decarbonisation is the cornerstone on which to develop the energy transition and decarbonisation of the economy although emissions of greenhouse gases generated outside the energy system, and to which the INECP devotes a great deal of attention, are also very important.

[6] Specifically in the electricity generation sector, the TIMES-SINERGIA model starts from the generation system existing in the base year and, from there, it satisfies the electricity demand of the other sectors seeking the economic optimum of the global energy system, within the horizon considered which is 2030. In order to do so, it installs new generation capacity taking into account all the costs and operating characteristics related to the different technologies considered (for a detailed explanation of the model, see Annex B).

The measures of the Integrated National Energy and Climate Plan 2021-2030 have the power to achieve a decrease in total gross GHG emissions from 327.4 $MtCO_2$-eq predicted for the year 2020 to 226.7 $MtCO_2$-eq in 2030. The sectors of the economy that, in absolute numbers, will reduce their emissions the most in this period are those of electricity generation (**44 $MtCO_2$-eq**) and mobility and transport (**28 $MtCO_2$-eq**), to which industry (combustion)[7] and the residential, commercial and institutional sector are added, with additional decreases of **7 $MtCO_2$-eq** in each of them. These four sectors considered together represent 86 % of the reduction of emissions in the 2021-2030 period.

In this sense, the Plan's forecasts regarding the decarbonisation of the electricity sector are that, as a consequence of the application of the European Union's market instruments (tCO_2-eq price of EUR 35 in 2030 at constant 2016 prices), coal plants will cease to provide energy to the system by 2030 at the latest, since they will have serious difficulty in being competitive with other technologies in an environment that is strongly conditioned by the European response to climate change, in which the cost of CO_2 will tend to be increasingly high. In any case, it is not ruled out that part of the installed capacity will be maintained where investments have been made to comply with the community framework and, for the sake of accounting prudence, this figure is reflected in the table relating to the evolution of installed capacity for electricity. At the same time, the disruptive reduction in the costs of electricity generation and storage renewables is altering the profitability assumptions of the different technologies significantly. This makes a carbon-free scenario in power generation virtually inevitable in the abovementioned 2030 horizon.

For the year 2030, the Plan foresees a total installed capacity in the electricity sector of **157 GW**, 50 GW of which will be wind energy; 37 GW solar photovoltaic; 27 GW combined gas cycles; 16 GW hydroelectric energy; 8 GW pumping; 7 GW solar thermoelectric; and 3 GW nuclear, together with smaller amounts of other technologies. The total renewable installed capacity for 2025 and 2030 is committed to in the Integrated National Energy and Climate Plan. However, the precise breakdown between the technologies presented in this document responds to the current projection based on the costs and assumptions considered in the modelling exercise (see Annexes A and B). The specific distribution between renewable technologies that takes place between 2021 and 2030 will depend, in any case, on their relative costs, as well as on the viability and flexibility of their implementation. Consequently, their relative weight may vary, within some margins, with respect to the figures presented in this Plan.

Renewable electricity generation in 2030 will be **74 % of the total**, consistent with a path towards a 100 % renewable electricity sector in 2050. With regard to storage, an increase in pumping technologies and batteries with an additional **6 GW** stands out, contributing greater capacity for managing generation.

Annex D of the Plan presents the results of the simulations of the dispatch of generation carried out by Red Eléctrica de España (REE), both for the Baseline Scenario and the Target

[7] Industry-Processes is the only sector of the economy that will increase its emissions (7 %) in the period of the Plan.

Scenario. Although the marginal average cost[8] should not be interpreted as a price, according to the simulations carried out by REE, the change in the electric mix provided for in the INECP 2021-2030 reduces the marginal average cost of generation by 18.5 % in the year 2030. A saving in the electricity system of EUR 1 758 million in 2030 results when compared to the Baseline Scenario. In addition, in 2030, CO_2 emissions in the electricity sector will have decreased by 21 million tonnes of CO_2 ($MtCO_2$-eq) compared to the Baseline Scenario.

It is important to highlight that the increase of the renewable generation capacity envisaged in this Plan will only be viable with the active involvement and full collaboration of the Autonomous Communities, which have competence in spatial planning, as well as the drafting of additional management rules in matters of protection of the environment, so that the development of the generation facilities is effective and compatible with the environment and the protection of biodiversity.

The mobility-transport sector contributed to 26.1 % of emissions in 2017. With the reduction of 28 Mt CO_2 equivalent, a reduction of 35 % is achieved. The main driving force behind the decarbonisation of the mobility-transport sector is a **modal shift that, according to the Plan, will affect 35 % of the passenger-kilometres that are currently carried out in conventional combustion vehicles**. The period provided for by the Plan will see the generalisation to all cities with more than 50 000 inhabitants of the ring-fencing of central zones with restricted access for the most emitting and polluting vehicles. The regional and local administrations will be key to these measures. Another driver of decarbonisation of the sector will be the presence of renewables in mobility-transport that reaches 22 % through electrification (**5 million electric vehicles in 2030**) and the use of advanced biofuels.

In addition, and in the longer term, the necessary measures will be adopted, in accordance with European regulations, so that new passenger cars and light commercial vehicles, excluding those registered as historic vehicles not intended for non-commercial uses, will gradually reduce their emissions so that **no later than 2040 they will be vehicles with emissions of 0gCO_2/km.** To this end, work will be carried out with the sector and measures will be put in place to facilitate the penetration of these vehicles. This will include measures to support research, development and innovation (RDI). Thus it is expected that in the two decades between 2021 and 2040, the national automotive sector can position itself in a flexible and smart way for the unavoidable European and international transition towards non-emitting vehicles.

Likewise, the Plan foresees that in the year 2030 the presence of renewables in final energy use will be **42 %**. This positive result will be a consequence (in terms of the numerator) of the high penetration of electric and thermal renewables in all sectors of the economy. This is based on measures that ensure visibility and stability in the medium term, greater flexibility and greater participation of citizens in the energy system, as well as specific support measures in those areas where necessary. As far as the denominator is concerned, it is also the result of the notable decrease in the amount of final energy required by the economy as a result of the progress obtained in savings and efficiency in the sectors as a whole.

The progress of renewables in the 2021-2030 period is strongly relevant in almost all economic sectors, as can be seen from the following data:

[8] Does not include extra-peninsular systems.

- electricity generation: increases from 9 793 to 20 988 ktoe;
- heat pumps: increases from 650 to 4 076 ktoe;
- residential: increases from 2 607 to 3 123 ktoe;
- industry: increases from 1 721 to 2 585 ktoe;
- transport (biofuels): evolves from 2 283 to 1 568 ktoe;
- services and other: increases from 355 to 596 ktoe;
- agriculture: increases from 94 to 278 ktoe.

Ultimately, the presence of renewables on energy end-use increases from **20 %** predicted for the year 2020 to **42 %** in 2030.

Apart from actions in the energy field, the Plan addresses the need to tackle emissions in **non-ETS non-energy sectors**, as well as to take advantage of the GHG absorption potential of sinks. With reference to non-ETS sectors, it proposes measures for non-energy sectors that can bridge the existing gap between the projected emissions and the commitments acquired by Spain for non-ETS sectors in the 2021-2030 period.

Finally, the Plan recognises the long-term climate benefits of the sector of land use, land-use change and forestry (**LULUCF**), and its contribution to the goal of emission mitigation by 2030.

Energy efficiency

The current INECP takes on the objective of improving energy efficiency by 32.5 % as formulated in the Energy Efficiency Directive, although in the projections of the Target Scenario of the Plan the reduction of primary energy consumption —with respect to the European baseline scenario PRIMES, which serves as a reference for setting this objective— it is **39.6 % in 2030**, so that the primary energy consumption does not exceed **98.2 Mtoe** in that year[9].

The reduction in primary energy consumption proposed in this Plan is equivalent to **1.9 %** annually since 2017, which when linked to an expected increase in Gross Domestic Product (GDP) in the same period of **1.7 %**, shows **an improvement of the primary energy intensity of 3.6 % per year until 2030.**

In addition to this objective, the Energy Efficiency Directive obliges Member States to demonstrate the achievement of an **objective of cumulative energy savings in the period:** firstly, between 1 January 2014 and 31 December 2020, and secondly, between 1 January 2021 and 31 December 2030. This cumulative objective of end-use energy savings has been calculated in accordance with the provisions of Article 7 of the Directive. For the first period, it amounts to 15 979 ktoe and for the second period, it is equivalent to **36 809 ktoe**, which means that new and additional savings are achieved every year, from 1 January 2021 to 31 December 2030, which are equivalent to **669 ktoe/year**.

The Plan also proposes that Public Administrations should exercise their responsibility proactively in the field of savings and energy efficiency. Thus, the Plan proposes initiatives for the fulfilment of the objective of renovation of the public building stock established in the

[9] Non-energy uses excluded.

Energy Efficiency Directive (3 %) and evaluates and promotes savings that can be obtained from the additional renovation of 300 000 m^2/year in the General State Administration. Likewise, and in accordance with the Energy Efficiency Directive, it encourages Autonomous Communities and local authorities, at least, to adopt the mandatory objective for the General State Administration of renewing 3 % of the built and heated area of the public building stock, as this will achieve a much more ambitious energy-saving objective.

This proactive and responsible position of the public sector is completed with the Ecological Public Procurement Plan of the General State Administration, its autonomous agencies and the Social Security management entities (2018-2025).

Energy security

Given the changes in the energy mix that are proposed in this Plan, supplying safe, clean and efficient energy to the different consumer sectors will involve significant challenges and technological difficulties, which must be addressed from the different dimensions that make up energy security:

- reduction of dependency, especially the importing of fossil fuels;
- diversification of energy and supply sources;
- preparation for possible supply limitations or interruptions;
- increase in the flexibility of the national energy system.

Specifically, and as regards the reduction of energy dependency, the starting point is energy consumption in 2017, of **132 Mtoe** in terms of **primary energy**, **99 Mtoe** of which were fossil fuels which were almost all imported.

After the application of the measures included in this National Plan, in 2030 it is foreseen that energy consumption of **103 Mtoe**[10] will be achieved, **63 Mtoe of which will be fossil fuels.** Consequently, renewables, efficiency and reduction of imports will lower the degree of dependency from **74 % in 2017 to 59 % in 2030.** In addition to improving national energy security, this will have a very favourable impact on the energy trade balance of Spain.

The lines of work included in this dimension of the Plan are the following:

- increasing the electricity interconnection of the systems, which will help reduce possible negative impacts due to supply limitations or interruptions;
- optimising the use of existing capacity by reducing barriers to the exchange of electricity (see the section on the internal market);
- increasing preparation for contingencies, which is currently very advanced, in the framework of the different international areas in which Spain is involved: International Energy Agency (IEA) and various EU directives and regulations for the electricity and gas sector;
- developing the National Security Strategy, through the recently created Special Committee on Energy Security (Comité Especializado de Seguridad Energética);

[10] Including energy consumption for non-energetic uses.

- adapting to the new European regulation on preparation against risks in the electricity sector;
- improving the different preventive and emergency plans in the field of electricity, gas and petroleum derivatives.

Internal energy market

The integration of renewable generation in the electricity sector, both on the mainland and in non-peninsular territories, makes the reinforcement and growth of the transport and distribution lines in Spanish territory necessary, including mainland connections, non-peninsular systems and interconnections between island systems. The Plan deals with all of these aspects, as well as the development of mechanisms for the management and storage of non-manageable electric renewables that will allow the prevention of discharges.

The increase in interconnections within the extra-peninsular electricity systems will have a direct impact on energy and climate, since in the production mix of these systems there is a greater contribution of coal, fuel or diesel power plants than in the mainland. In this regard, the Plan foresees **that the contribution of fossil fuel plants located in isolated electrical systems will be reduced by at least 50 % by the year 2030.**

At an EU level, the degree of interconnection of the Iberian electricity system with the rest of the European continent is below the established objectives. **Currently, the interconnection ratio of Spain is less than 5 %** of the generation capacity installed in the system. In 2020, despite the planned interconnections, Spain will be **the only one in the European Union that falls below the 10 % objective**, so it will be necessary to continue developing new interconnections:

- A new interconnection with Portugal, which will increase the exchange capacity to 3 000 MW.
- New interconnections with France, which will increase interconnection capacity to 8 000 MW:
    - the project of the Bay of Biscay: between Aquitaine (FR) and the Basque Country (ES);
    - an interconnection between Aragon (ES) and Pyrénées-Atlantiques (FR);
    - an interconnection between Navarre (ES) and Landas (FR).

Finally, the Plan takes into account the new **National Strategy against Energy Poverty** on which it is currently working and which will be available in April of this year (Royal Decree-Law 15/2018 of 5 October 2018 on urgent measures for energy transition and the protection of consumers). This Strategy is configured as an instrument used to address the phenomenon of energy poverty from an integral perspective and with a medium and long-term vision.

Research, innovation and competitiveness

The Energy Union incorporates research, innovation and competitiveness in which the **Strategic Energy Technology Plan (SET-Plan)** plays a leading role. This has been the pillar of R&I for European policy on energy and climate since 2007.

Through the SET-Plan, the actions of innovation and research in low-carbon technologies are coordinated among the participating countries. These are those of the European Union, as well as Norway, Iceland, Switzerland and Turkey. Financial support for projects arising from the SET-Plan is found in the Horizon 2020 programme. Within the SET-Plan framework, Spanish administrations work in different groups that address the needs of research, innovation and competitiveness (RIC) in sectors such as photovoltaic energy, solar concentration, wind, and the capture, storage and use of carbon.

In Spain, the Ministry of Science, Innovation and Universities is the department of the General State Administration responsible for executing the Government's policy on scientific research, technological development and innovation; for this reason, it is responsible for developing this dimension in the energy sector and coordinating the agents involved. Together with the Ministry, the following participate in this role:

- The State Research Agency, responsible for the financing, evaluation, granting and monitoring of scientific and technical research activities. Technological platforms stand out among its actions.
- The Industrial and Technological Development Centre (Centro para el Desarrollo Tecnológico e Industrial- CDTI), which aims to increase the competitiveness of Spanish companies by raising their technological level, for which it funds business RIC projects.
- Public Research Organisations, such as the Centre for Energy and Technological Research (Centro de Investigaciones Energéticas y Tecnológicas, CIEMAT), which focus on the execution of programmes.

The RIC activities aimed at combating climate change and promoting energy transition are articulated in the following lines of work:

- Energy Efficiency, characterised by its cross-cutting nature in terms of the technologies and sectors affected.
- Renewable energy technologies:
  - Those in which Spain already has a competitive position, with a high level of participation of its companies, such as wind, solar photovoltaic and solar thermoelectric.
  - Renewable fuels for the transport sector, particularly, the development of advanced biofuels.
  - Others in which Spain has significant natural resources and sufficient local implementation potential to develop technological learning curves: off-shore wind energy, biomass, marine energy, waste, as well as low enthalpy geothermal energy.
- Flexibility and optimisation of the energy system through the implementation of technologies that provide flexibility to the electricity system, which is essential to achieve a high degree of penetration in the non-manageable renewable generation system.
  - Electricity storage, with and without electric vehicles, and participation of the demand in system operation. In that sense, it is important to promote the development of a national system for the manufacture of this equipment, for which investments in RIC will be required.

  - Thermal storage for solar thermal technologies.
  - Hydroelectric storage.
  - Chemical storage in the form of hydrogen, either by using electrolysis and consumption in fuel cells, or by injecting it into the network.
- Electric vehicles: batteries and the installation and optimisation of charging points.
- Capture, storage and use of carbon.

The economic, employment, distributive and health impact of the INECP, 2021-2030

An important aspect of the energy transition underpinned by this National Plan is the economic and employment opportunity it entails for Spain, as shown by the impact analysis of the INECP (see Chapter 4).

The evaluation study carried out differentiates between a Baseline Scenario (with a 10 % increase in GHG emissions in 2030 compared to 1990); and a Target Scenario (with the additional measures of the Plan), in which the reduction of emissions reaches 20 % compared to 1990. The impact of these additional measures is what is analysed in the evaluation study. The main results of the above are the following.

The total investments to achieve the objectives of the Plan will reach EUR 236.124 billion between 2021 and 2030. Of this amount, EUR 195.310 billion are additional investments compared to the Baseline Scenario. The total investments are distributed between:

- investments in savings and efficiency: 37 % (86.476 billion);
- renewables: 42 % (101.636 billion);
- networks and electrification of the economy: 18 % (41.846 billion);
- non-energy non-ETS and other electricity: 3 % (6.166 billion).

According to the study carried out, **80 % of the investment will be made by the private sector and only 20 % by the public.**

The INECP will generate an **increase in GDP, compared to the Baseline Scenario, of between EUR 19.3 and 25.1 billion per year** (1.8 % of GDP in 2030). This positive impact comes from the economic boost generated by investments in renewables, savings and efficiency and networks, on the one hand, and the significant decrease in the country's energy bill, on the other.

The Plan's effect on employment compared to the Baseline Scenario (without the INECP) shows a significant positive balance every year throughout the decade, reaching **364 000 additional jobs in 2030.**

Regarding the trade balance, the Plan promotes **cumulative savings in fossil fuel imports of EUR 75.379 billion between 2021 and 2030**, when compared to the Baseline Scenario.

In the case of distributive impacts, **the measures favour low-income households, particularly, vulnerable groups.** The evaluation of the economic impact of the Plan confirms how the effect on final consumption increases to a greater extent in the lowest income quintiles, that is, the INECP measures have a progressive effect. The evaluation also shows a positive effect on vulnerable consumers, since energy expenditure involves a higher percentage of their disposable income.

Finally, the health benefits of people from the measures identified to achieve climate and energy goals have been analysed: in particular, the improvements that result from the reduction of atmospheric pollutants emitted as a result of the combustion of fossil fuels. According to the analysis carried out, **a decrease of 2 222 premature deaths** is expected in the year 2030 compared to the Baseline Scenario (without additional policies), with the corresponding significant economic co-benefits in terms of public health.

Process for the development of the Plan

The strategy that Spain has set in motion in the preparation of this INECP 2021-2030 has, as its starting point, the decision of the new Government formed in June 2018 to integrate the areas of energy, climate change and the environment into a single ministry, for the first time in Spain's history. In this way, the foundations of institutional governance have been established in order to combine the objectives and policies of energy and climate change coherently under the same strategic vision. On the basis of this starting point and in order to advance in the five dimensions considered in the Plan, the following steps have been developed:

In the first place, considering the present Plan as a key element for Spain to adequately and responsibly fulfil the requirements arising from the **Paris Agreement**.

Second, the full interrelation and consistency between this Plan and the **2050 Low Emissions Strategy** of the Spanish Economy, a long-term decarbonisation roadmap that Spain will present in 2019 as a consequence of the obligations assumed by the European Union within the framework of the Paris Agreement. In this way, an alignment between the medium (2030) and long-term (2050) approaches is produced.

Third, the Plan will be accompanied by the **Just Transition Strategy**, aimed at foreseeing and managing with solidarity criteria the consequences on those regions and people directly linked to technologies that will be gradually displaced as a result of the energy transition promoted by this Plan.

Fourth, the involvement of the different ministries has been sought through the constitution and periodic meetings of the **Interministerial Commission on Climate Change and Energy Transition (Comisión Interministerial de Cambio Climático y Transición Energética)**, as well as through numerous specific bilateral meetings to discuss and assess the measures and instruments necessary to achieve the objectives of the Plan.

Fifth, coordination with the Autonomous Communities will be promoted through the **Climate Change Policy Coordination Commission** throughout 2019, in order to identify the interrelation of this Plan with regional policies, seeking the full involvement of each area of the administration in order to meet its objectives.

Sixth, numerous meetings have been held with business entities, social and environmental organisations, as well as with the most relevant companies in the energy system. We also plan to carry out an information and participation process that is open to the public when the Plan is sent to the Commission. In addition, throughout 2019, the **Strategic Environmental**

Assessment of the Plan will be carried out and a second phase will be opened in the process of public consultation.

Seventh, in its first area, Decarbonisation, the National Plan is focused on reducing greenhouse gas emissions in the economy. However, the Plan is also connected to the other major aspect of climate change, which is adaptation to the pressures and impacts arising from it (see Annex C for a detailed list of current climate policies in Spain). In that sense, the climatic aspiration of Spain and its impact on greater ambition on the part of the European Union and the international community will have a positive indirect effect on the preservation of natural systems and biodiversity. At the same time, when deploying the important developments of renewable technologies provided for in the Plan, Spain is committed to protecting the natural heritage in a responsible manner, particularly through the **protection of its biological diversity**, which is one of the highest and most valuable in the European Community.

Eighth, one of the risks that creates greatest concern to industry in the European Union in relation to climate action is that the regulation and the existing and future price signals to reduce greenhouse gas emissions will damage its competitiveness if its relative production costs are increased. This risk is higher for those sectors that are intensive in energy consumption and more open to global competition. Aware of this risk, the European Union has established that the sectors considered to be exposed can receive special treatment so as not to affect their competitiveness. To this end, it drew up a list of sectors included in the CO_2 market (EU-ETS) and in the 2013-2020 period they received a higher quota of free allocations than other industrial facilities. Installations in sectors exposed to a significant risk of carbon leakage can receive free allocations for 100 % of their production volume.

Recently, and within the 2030 Climate and Energy Framework, the European Commission has prepared a new updated list of exposed sectors and has decided to maintain the free allocation of emission allowances until 2030. Likewise, Member States have the possibility of compensating the electro-intensive sectors by means of state aid programmes to reimburse them for the indirect costs associated with climate policies, provided these programmes comply with European regulations and have the approval of the Commission. In this regard, and although the protection of these sectors included in the EU-ETS is regulated at the level of the European Union, the Integrated National Energy and Climate Plan 2021-2030 contends that progress towards high standards in the regulatory or fiscal field in Europe requires the establishment of measures, in particular as regards imports, **ensuring that there will be no displacement of emissions to other regions** (carbon leakage), as well as a level competitive playing field for companies globally.

In ninth place, **the Plan is strongly committed to a gender perspective.** According to recent studies by the International Renewable Energy Agency (IRENA), it is estimated that the percentage of women in total renewable energy jobs in the international sector is 32 %, while that percentage in Spain is 26 %. This is a lower percentage than that in the economy as a whole and is similar to the percentage in the industry as a whole. Taking into account the competition between sectors of the economy for attracting talent, the fact that the number of graduates or postgraduates in technical matters remains constant in Europe and the need for a skilled workforce for the implementation of the Plan, it follows that the incorporation of women into the renewable energy sector is not just an opportunity, but a necessity.

Tenth, the Integrated National Energy and Climate Plan 2021-2030 is fully connected to the **Sustainable Development Goals** (SDG) agenda. Although the Plan has an especially direct impact on SDGs 7 and 13 (affordable and clean energy for all people and climate action, respectively), interactions with the other SDGs are important as explained in Annex E in which the actions provided for in this Plan are connected with the different Sustainable Development Goals.

Finally, regarding the **analytical basis of the Plan**, a large team of experts was set up with people from different departments of the Ministry for Ecological Transition (MITECO), which in turn had the technical assistance of academic and advanced research centres with extensive experience and knowledge in the fields of economics, energy and climate change, as well as the important collaboration of Red Eléctrica de España (see Annex D). The working group has met once or twice a week during the seven months dedicated to the preparation of the Plan.

Political, economic, environmental and social context of the National Plan

During the last few years, Spain has resumed a path of economic growth. This recovery was reflected in 2018 for the fifth consecutive year. GDP grew by 2.6 % that year, a rate that is slightly lower than those observed in previous years. However, progress in reducing external debt and, above all, public debt is still modest and the persistence of this debt represents an element of vulnerability, although the Government maintains a forecast of a 2.2 % increase in GDP for this year, 2019.

The effort to consolidate and improve what has been achieved so far is significant. For example, the financial system still faces significant socio-economic challenges. Population ageing is also a first-level challenge for the sustainability of public finances, since the most recent estimates point to an increase in spending in the next three decades, with a maximum of 3.5 GDP points by 2050. Another factor that restricts growth in the Spanish economy is a high structural unemployment rate (which persists in groups such as those of young people, older people, and those with lower qualification levels). Although economic expansion is allowing rapid growth in employment and a significant reduction in the unemployment rate, the latter rate still has very high levels - currently at around 15 %.

For their part, the final prices of electricity have seen significant increases in recent months arising from high prices of raw materials (natural gas, oil, coal) in international markets, as well as an increase in the price of CO_2 emission allocations (related to the EU climate policy in the context of the Paris Agreement). Therefore, by way of example, electricity prices in the Iberian wholesale market recorded an average value of EUR 71.35/MWh in September 2018, approaching the monthly historical maximum reached in 2006 of EUR 73.14/MWh.

Finally, and as regards GHG emissions, the emissions of the European Union have been progressively decreasing, reaching a level in 2017 that is 23 % lower than that of 1990, while in Spain, despite the fact that emissions have been reduced by 25 % compared to the highest levels recorded in 2007, at the end of 2017 their level was 18 % higher than that of 1990, the reference year.

1.2 OVERVIEW OF THE CURRENT POLICY SITUATION

1.2.1 National and European Union energy system. Political context of the Integrated National Energy and Climate Plan

The framework for energy policy in Spain is determined by the international context and the policy of the European Union. The Paris Agreement that was reached in 2015 and has been the most ambitious international political response so far when facing the challenge of climate change, stands out here. It is common knowledge that the central objective of the aforementioned Agreement is to keep the increase in the global average temperature of the Earth's surface below 2 ºC compared to levels existing before the industrial revolution, while making efforts to limit it to 1.5 ºC[11]. The EU ratified the Agreement in October 2016 (which allowed its entry into force in November 2016) and Spain followed in 2017. By means of this entry into force, the starting point for policies on energy and climate change in the near future was established.

With a view to the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), the European Council of October 2014 agreed on the framework for EU action on climate and energy until 2030. Taking into account this time horizon, an internal objective applicable to the whole economy was established. This consisted of reducing GHG emissions by at least 40 % when compared to 1990 levels. In addition, amendments were proposed to the **European Union Emission Trading Scheme** (EU ETS) and measures for sectors not subject to this scheme were proposed, as well as objectives on the share of renewables in final energy consumption, improvement of energy efficiency and interconnections.

In order to achieve these objectives, to accelerate the transition to a low-carbon economy, to comply with the Paris Agreement and to move towards the achievement of the Energy Union in its five dimensions (decarbonisation (renewables), energy efficiency, energy security, internal market and RIC), the European Commission prepared a series of legislative proposals presented in 2015 and 2016:

- review of the EU ETS legislative framework for its next trading period (phase 4);
- effort-sharing between the Member States in order to meet the common objective of reducing emissions in sectors not covered by the Emissions Trading Directive (proposed European Regulation);
- inclusion of GHGs and sinks from land use, land-use change and forestry (LULUCF), in the Climate and Energy 2030 framework (proposed European Regulation);
- the set of proposals known as the 'winter package' (**Clean energy for all Europeans,** COM2016 860 final) that included reviews and legislative proposals on energy efficiency, buildings, renewable energies, electrical market design, security of supply and governance rules for the Energy Union.

Most of the previous proposals have already been approved within the European institutions so that the new regulatory framework provides regulatory certainty and favourable conditions

[11] The latest report of the Intergovernmental Panel on Climate Change confirmed that the observed increase in the average temperature of the planet exceeds 1º C when compared to the average temperature of the pre-industrial era.

for investment to take place, empowers European consumers to become fully active players in the energy transition and sets binding targets for the EU in 2030[12]:

- 40 % reduction in greenhouse gas (GHG) emissions compared to 1990;
- 32 % total gross final energy consumption from renewables, for the entire EU;
- 32.5 % improved energy efficiency;
- 15 % electricity interconnection between the Member States.

As regards the remaining dimensions of the Energy Union, it should be noted that under energy security the form of action in case of supply limitation is defined, and objectives are set in order to increase the diversification of energy and supply sources, as well as to reduce energy imports. In the case of Spain, given the prevalence of fossil fuels in the national energy mix, the energy system is characterised by high energy dependency: it reaches 74 %, which is well above the EU average (54 %). Therefore, in 2017, the net balance of foreign trade in energy was unfavourable to Spain by EUR 20 billion. On the positive side, Spain has one of the highest levels of diversification of gas and petroleum suppliers in Europe.

With regard to the internal market, the objective of electricity interconnection of the Member States is set at 15 %. In research, innovation and competitiveness, national financing objectives are set for both public and private research and innovation matters. Finally, on the 2050 horizon, on 28 November 2018 the European Commission updated its roadmap towards a systematic decarbonisation of the economy with the intention of making the European Union carbon neutral by 2050.

Regarding the analysis of final energy demand by sector in Spain[13] we point out that in 2017, transport was the sector with the highest energy consumption of 40 % of total final demand. The demand of the industrial sector was 24 %. The category called ‘mixed uses’, which includes the ‘residential, services and agriculture’ sectors, reached 33 % of the total.

Electricity generation in 2017 was 32% sourced from renewable resources. Among renewable electricity production, wind (18 %) and hydroelectric energy (7 %) stood out. The rest originated mainly from photovoltaic, solar thermoelectric and biomass contributions.

We also wish to point out that the provisional energy balance data for 2017 confirmed that energy consumption growth was continuing. This consolidates the change in trend that began in 2014, after seven consecutive years marked by a reduction in demand.

Finally, an improvement in the final energy intensity was observed (energy consumption per economic unit generated) with a reduction of 0.8 % in 2017 when compared to 2016.

[12] The objectives of renewable energy, energy efficiency and electricity interconnection may be revised upwards in 2023.

[13] The data provided below are temporary since, at the time of writing this draft of the Plan, the Spanish Energy Balance of 2017 is not yet available in its final version. If applicable, this data will be updated for the final version of the INECP 2021-2030 which will be sent to the European Commission before the end of 2019.

1.2.2 Current energy and climate policies and measures relating to the five dimensions of the Energy Union

Decarbonisation of the economy

The decarbonisation policies and measures that have been developed to date have been embedded in the Spanish Strategy on Climate Change and Clean Energy (Estrategia Española de Cambio Climático y Energía Limpia), which was approved by the Council of Ministers on 2 November 2007 and designed with a time horizon of 2020. Subsequently, the entry into force of the new European framework with the definition of objectives in 2020 resulted in an expansion of the aforementioned strategy with new planning instruments that are listed below (see links to the documents):

- Road map to 2020 for the non-ETS sectors.[14, 15]
- Information on actions in the land use, land use change and forestry sector in Spain.[16]
- Report on progress made in the implementation of actions in the land use, land use change and forestry sector in Spain.[17]
- National plan for adaptation to climate change.[18]
- Third work programme of the National plan for adaptation to climate change.[19]

In the case of GHGs in **non-ETS sectors** (residential, transport, agriculture, waste, fluorinated gases and industry not subject to emissions trading), this capacity was reflected in the Roadmap to 2020 for non-ETS sectors which was published in September 2014. This consists of an analysis of the scenarios of future emissions and their comparison with the objectives arising from the Decision on effort-sharing in the EU (Decision 406/2009/CE), specifically with the objective of reducing non-ETS emissions by 10 % in 2020 when compared to 2005 levels. The analyses carried out have made it possible to identify the existing gap in order to fulfil said reduction commitment. Consequently, the options and additional action measures are raised. If implemented with the appropriate degree of intensity they will allow Spain to meet the 2020 objectives in a cost-efficient manner.

The existing policies and measures at national level, which were adopted and/or implemented to date in terms of decarbonisation or with an impact on GHG reduction, are distributed between different sectors and departments. The detailed list of these can be found in Annex C. Additionally, there are Autonomous Communities and local authorities that have put in place ambitious energy and climate plans and measures falling under their areas of competence.

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[14] https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/Hoja%20de%20Ruta%202020_tcm30-178253.pdf

[15] https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/HojaRuta2020_Fichas_tcm30-178314.pdf

[16] https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/acciones_lulucf_espana_def_tcm30-178767.pdf

[17] https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/informe_progreso_utucts_es_2017_tcm30-178397.pdf

[18] https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/pna_v3_tcm7-12445_tcm30-70393.pdf

[19] https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/3PT-PNACC-enero-2014_tcm30-70397.pdf

We highlight the implementation in non-ETS sectors of the **Climate Projects** promoted through the **Carbon Fund for a Sustainable Economy** (FES-CO_2) and designed to forge a path of transformation of the Spanish productive system towards a low carbon model, as well as the **Environmental Promotion Plans** (Planes de Impulso al Medio Ambiente), known as PIMA, which are measures for combating climate change at a national level. The creation of a tax on fluorinated gases that has allowed a rapid transformation in this sector by drastically reducing its emissions is equally noteworthy.

As for the sectors subject to emission rights trading, the European scheme is regulated by Law 1/2005 of 9 March 2005 as well as by various Royal Decrees that develop this law. This scheme affects around **900 industrial and electricity-generation installations in Spain.** Likewise, Spain has been assigned the management of more than 30 active air operators, approximately half of which are foreign.

In the field of renewables, the **Renewable Energy Plan (REP) 2011-2020** in force establishes objectives in accordance with Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources. The REP aims to achieve **at least 20.8 % of the final gross energy consumption from the use of renewable sources by 2020** (39 % of total electricity consumption) and a contribution from these sources to consumption of **transport of 11.3 %** in the same year. This results in exceeding the mandatory minimum targets established for Spain in the Renewable Energy Directive.

In Spain, the regulations regarding the promotion of renewable energies have undergone numerous changes in recent years. In 2013, urgent measures were enacted to guarantee the financial stability of the electricity system, with the aim of containing the growing tariff deficit. These measures included an important reform of the electricity sector and a mandate for the Government to approve a new legal and economic scheme for installations producing electricity from renewable energy sources, cogeneration and waste. All this resulted in a reduction in the remuneration of these technologies, abruptly slowing down their development. However, the need to meet the aforementioned renewable energy objective in 2020 gave a new impetus to their deployment. To this end, a specific remuneration scheme was established in order to encourage production from renewable energy sources, high efficiency cogeneration and waste on the basis of competitive tendering procedures (auctions).

Therefore, in 2016 notice was given of the first auction for the specific remuneration scheme for new installations producing electricity from renewable energy sources in the mainland's electricity system. Since then, two more auctions have been carried out and **9 292.4 MW of new renewable capacity** have been assigned as a result.

Likewise, with the approval of **Royal Decree-Law 15/2018**, an exceptional extension was granted to the access permits and electrical connection of renewable energies previously granted that would otherwise have expired on 31 December 2018. By means of this extension, it will be possible to begin operating all renewable installed capacity granted in the latest adjudications in 2020, while avoiding the bureaucratic process that would have hindered the achievement of the 20.8 % objective by that year.

Additionally, the policy of promoting renewable energies develops and strengthens existing synergies with other measures recently approved in the aforementioned Royal Decree-Law 15/2018 aimed at improving the protection of energy consumers, promoting sustainable mobility through electric vehicles, liberalising recharge activity and boosting renewable electric self-consumption.

On this last point it should be noted that in Spain the activity of self-consumption has barely taken off yet, owing to the existence of a series of regulatory barriers that have hindered its economic viability. However, the new measures allow the recognition of the right to self-consumption of electricity without charges and the right to shared self-consumption by one or several consumers in order to take advantage of economies of scale; and administrative procedures for small-scale installations are simplified. All this is carried out with the aim of facilitating the process so that the consumer can obtain cleaner energy at a lower cost.

For its part, support for renewable energy sources for heating, cooling and electrical production isolated from the grid is mainly put into practice through grants from the Autonomous Communities for installed capacity. Additionally, existing programmes for financing projects have continued in the area of financial aid for renewable energies. These are mostly **managed by the Institute for Energy Diversification and Saving (Instituto para la Diversificación y Ahorro de la Energía - IDAE) of MITECO.** These are integrated actions aimed at promoting the use of renewable energies (solar, biomass and geothermal energy) in the residential and tertiary sectors and encouraging energy savings and the improvement of energy efficiency in existing buildings.

As to the promotion of the use of biofuels, its most recent impetus was set at the end of 2015 (Royal Decree 1085/2015 of 4 December 2015 on the promotion of biofuels) via new minimum and mandatory annual sales or consumption objectives (4.3 %, 5 %, 6 %, 7 % and 8.5 %, for the years 2016, 2017, 2018, 2019 and 2020, respectively). Obligated undertakings can achieve them in a flexible manner through certificates of biofuel in diesel or in gasoline interchangeably.

Finally, it should be noted that among recent initiatives to reduce emissions, a **framework agreement for the coal sector** was reached and signed on 24 October 2018 between the Government, trade unions and representatives of the sector. The main objective of this agreement was **to promote a just transition from coal mining and to promote the sustainable development of mining regions during the 2019-2027 period.** The agreement responds to social repercussions arising from compliance with Decision 2010/787/EU of the European Council, which requires the closure of coal mines in European Union territory or, otherwise, the return of state aid received in the 2011-2018 period.

Energy efficiency

The energy efficiency policy is set up through the **National Energy Efficiency Action Plan 2017-2020** (which follows the National Energy Efficiency Action Plan 2014-2020), sent to Brussels in April 2017. This responds to the requirement of Article 24(2) of the Energy Efficiency Directive 2012/27/EU of the European Parliament and the Council of 25 October 2012, which requires all Member States of the European Union to present the first plan no later than 30 April 2014, and the remaining plans every three years.

Current measures to promote energy efficiency include a range of legislative and/or economic support actions, aimed at producing a general or specific impact on each consumer sector. The most important structural decision was the establishment of the system of energy efficiency obligations, together with the creation of the **National Energy Efficiency Fund** (Fondo Nacional de Eficiencia Energética - FNEE), in order to finance national energy efficiency initiatives (as provided in Royal Decree Law 8/2014 of 4 July 2014 on the approval of urgent measures for growth, competitiveness and efficiency).

The FNEE, managed by the IDAE, has the purpose of funding support mechanisms for economic and financial aid, technical assistance, training, information or other measures in order to increase energy efficiency in the different energy-consuming sectors, in a way that contributes to achieving the national energy-saving objective established by the national system of obligations provided for in Article 7 of the Energy Efficiency Directive.

The promotion of energy efficiency in cities had two main components or lines of action: buildings, on one hand, and mobility of passengers and goods on the other. The actions to improve energy efficiency of buildings have been framed within the **long-term Strategy for energy upgrading in the building sector in Spain**[20], which includes different pieces of legislation. This is the case of the Technical Building Code [21] (Código Técnico de la Edificación - CTE), the Regulation of Thermal Installations in Buildings [22] (Reglamento de Instalaciones Térmicas en los Edificios - RITE) or the Energy Certification System of Buildings,[23] among others. Within the building sector, the **Aid Programme for the energy upgrading of existing buildings** (PAREER-CRECE Programme) and the JESSICA-FIDAE Fund, both managed by the IDAE, stand out. The latter funded urban projects for energy efficiency and the use of renewable energies. Energy efficiency in cities is also established by the public administration through integrated strategies of sustainable urban development (desarrollo urbano sostenible - DUSI) aimed at urban functional areas.

Actions to improve energy efficiency in transport and sustainable mobility in cities aimed at encouraging the modal shift in mobility of people and goods to those methods that consume less energy per passenger-km or tonne-km. These also included actions aimed at improving efficiency of the fleet of vehicles through fleet renewal and the incorporation of technological advances, as well as actions aimed at the efficient use of the modes of transport. Additionally, the promotion of high efficiency cogeneration and urban heating and cooling networks, as well as energy-efficiency measures in transformation, transport, distribution and participation in demand have been part of the comprehensive strategy of energy-efficiency in cities.

For its part, energy-efficiency in non-urban environments and, therefore, in sectors other than those of construction or transport has had support measures tailored to the specificities of each sector. Therefore, for example, a policy of financial support for industrial investment has prevailed in the industry within the framework of public policy in order to promote industrial competitiveness. In addition, there have been and currently are aid programmes for SMEs and large companies which are funded by the National Energy Efficiency Fund. These programmes aim to encourage and promote the performance of actions in the industrial sector that reduce

[20] 2014 ERESEE, as development of Article 4 of the Energy Efficiency Directive.
[21] Royal Decree 314/2006 of 17 March 2006.
[22] Royal Decree 1027/2007 of 20 July 2007 updated by Royal Decree 238/2013 of 5 April 2013 which amends certain articles and technical instructions of the RITE.
[23] Royal Decree 235/2013 of 5 April 2013.

carbon dioxide emissions by improving energy efficiency, in order to reduce final energy consumption.

In short, the implementation of measures of the National Action Plan for Energy Efficiency 2017-2020 and previous plans contributed to an improvement in energy efficiency which was reflected during the period 2004 to 2016 and **quantified in an annual decrease of 2 % in final energy intensity.**

Energy Security

As indicated above, Spain depends heavily on foreign sources for energy - 74 % in 2017 - due to the prevalence of fossil fuels in its energy mix that have to be imported in their entirety given that national production is almost nil. The imports of hydrocarbons are, therefore, very important in the field of energy security, which is understood as security of supply.

The presence of natural gas in the Spanish energy balance is slightly lower than that of other EU Member States for the following reasons:

- a milder climate, resulting in lower penetration of natural gas between domestic consumers and central heating;
- greater significance of natural gas in the generation of electricity, which means that its presence in final energy is clearly lower than the share in primary energy.

As for petroleum products, their presence in the national energy mix is much higher than the EU average, due to the following causes:

- high development of freight transport by road to the detriment of rail transport (2 % on average in Spain, compared to an average of 17 % in the EU);
- significant consumption of maritime transport when compared to Member States that are almost landlocked;
- significant consumption of air transport due to the considerable importance of the tourism sector.

With reference to the national production of hydrocarbons, it should be noted that this is practically non-existent. Data for 2017 are as follows:

- Domestic production of natural gas (2017): 23 ktoe (0.09 % of needs). Domestic production is considered as not only the production of hydrocarbon deposits, but also the injection of biogas into the transport network.
- Domestic crude production (2017): 122 000 tonnes (0.21 % of needs).

The main countries of origin for the different sources of energy are the following:

- Electricity: Spain has electricity interconnections with France, Portugal and Morocco.
- Natural gas: in 2017, 60 % of imports were made through gas pipelines, compared to 40 % in methane tankers (in the form of Liquefied Natural Gas through regasification plants). Currently, the most important international pipelines are Maghreb (Maghreb-Europe), Medgaz (Algeria-Almeria) and the interconnections with France and Portugal. The breakdown of imports of natural gas in 2017 by country of origin was as follows:
  - Algeria (48 %)

- Nigeria (12 %)
- Peru (10 %)
- Qatar (10 %)
- Norway (10 %)
- Others (10 %)

- Petroleum products: the main countries of origin for crude oil in 2017 were the following:
  - Mexico (15 %)
  - Nigeria (14 %)
  - Saudi Arabia (10 %)

In view of the foregoing, the relative dependence on the importation of natural gas from Algeria can be highlighted as a possible risk, which is compensated for by the high level of imports by methane tankers from a wide range of countries of origin. That is, Spain has one of the highest levels of diversification of gas and petroleum suppliers in Europe.

It should also be pointed out that regional cooperation for energy supply is a fundamental element in the stability and prosperity of the countries and regions surrounding Spain. They form the basis of the regional cooperation platform called 'Union for the Mediterranean', of which Spain is a member.

At its Ministerial Conference in Italy (1 December 2017), three new energy platforms were approved: one aimed at the gas market, another at the regional electricity market, and a third focused on renewable energies and energy efficiency. The objective was to organise and strengthen the dialogue between the Member States of the Mediterranean region, its financial institutions, experts, regional organisations and industry.

Domestic energy market: interconnectivity, infrastructure and market

Planning of the electricity transmission infrastructure is governed by the **2015-2020 Electricity transport network development plan**, which includes the necessary infrastructures to safeguard security of supply in the 2015-2020 planning horizon. It introduces environmental and economic efficiency criteria and establishes safety and reliability requirements for the electricity network, with the aim of increasing the international connection capacity and, consequently, the integration of Spain in the single energy market.

The current plan integrates renewable energies in the network, in order to encourage the fulfilment of the objectives on this matter for 2020, and it is adapted to the demand needs arising from new industrial activity. Investments associated with electrical infrastructures in the 2020 horizon are predicted to be an estimated EUR 4.554 billion, with an average annual investment volume of EUR 759 million, of which EUR 143 million are expected to be recovered from ERDF Funds throughout the period.

With regard to national interconnections, it should be noted that apart from those already existing between the island of Mallorca and the peninsula, the Mallorca-Ibiza interconnection (132 kV double link, Torrente-Santa Ponsa) has been in service since December 2018. This gives rise to the union of the two current electricity sub-systems Mallorca-Menorca and Ibiza-

Formentera, thus allowing their joint operation. This results in a greater integration of renewable energies in the Balearic system.

With reference to cross-border electricity interconnections, work that has been carried out to extend the interconnections with France has brought a new line into service in the east of the Pyrenees. This has doubled the electricity exchange capacity between Spain and France (from 1 400 MW to 2 800 MW). It has helped to strengthen security of the two electricity systems and to favour the integration of a greater volume of renewable energy, especially wind power from the Iberian system.

However, despite this expansion, the level of electricity interconnection between Spain and France is less than 3 % of installed capacity of electricity production in Spain. This falls far short of the objectives of the Energy Union: **10 % of the installed capacity of electricity production for all Member States in the 2020 horizon and 15 % in 2030.** With the interconnections planned to date, by 2020 Spain will be the only country in continental Europe with a level of interconnection of less than 10 %. It will therefore be necessary to continue developing new interconnections.

To this end, and in the framework of collaboration initiated with the 2015 Madrid Summit, an increase in the interconnection capacity with France is planned with the following extensions:

- an interconnection between Aquitaine (FR) and the Basque Country (ES), through a submarine cable through the Bay of Biscay, which will allow the interconnection capacity between Spain and France to reach 5 000 MW;
- an interconnection between Aragon (ES) and Pyrénées-Atlantiques (FR) and an interconnection between Navarre (ES) and Landas (FR), which will increase the interconnection capacity between Spain and France to 8 000 MW.

Finally, and with respect to the transport of hydrocarbons, since there is no specific regulation for the planning of the basic natural gas network, the planning of its network has been carried out jointly with electricity in recent years. In 2018, and following the criteria established by the National High Court (Audiencia Nacional) in its judgments of 31 October 2012, the parties of both plans are already independent.

Finally, the future planning of the natural gas transmission infrastructures will be carried out once the new regulatory development of the hydrocarbon sector is approved. This will include the procedure for it. So far, the basic regulation is contained in Law 34/1998 of 7 October 1998 of the Hydrocarbons Sector, as well as in the provisions of Articles 79 and 80 of Law 2/2011 of 4 March 2011 on sustainable economy. The reference document is the Plan for the electricity and gas sectors 2008-2016, approved on 30 May 2008 by the Agreement of the Council of Ministers.

This document, based on an analysis of the sector and forecasts of the demand, establishes criteria for development of the basic natural gas network, points of entry, and technical criteria for the design of gas pipelines and storage capacity. In this current plan, the need for new transport capacity, storage and regasification infrastructures is analysed and identified, designing the main aspects in such a way that a safe and flexible system is established whereby all the gas zones are communicated together.

Research, innovation and competitiveness

The Ministry of Science, Innovation and Universities (Ministerio de Ciencia, Innovación y Universidades, MITECO) is the department of the General State Administration responsible for executing the Government's policy on scientific research, technological development and innovation in all sectors. For this reason, it is responsible for developing the RIC policy in the energy sector and coordinating all the involved agents.

The framework for action in the field of research, development and innovation is defined in two fundamental documents of scientific, technological and innovative policy: **the Spanish Strategy for Science, Technology and Innovation 2013-2020 (Estrategia española de ciencia y tecnología y de innovación - EECTI) and the State Plans for scientific research and technical research and innovation.**

The Spanish Strategy for Science, Technology and Innovation 2013-2020 (EECTI) is the instrument that establishes the general objectives to be reached during the 2013-2020 period relating to the promotion and development of RIC activities in Spain. These objectives are aligned with those established by the European Union within the framework programme for the financing the '**Horizon 2020**' RIC activities for the period 2014-2020, helping to encourage the active participation of the agents of the **Spanish Science, Technology and Innovation System** in the European area. It also includes coordination between the actions of the General State Administration, the Autonomous Communities and the European Union, at the same time as proposing efficient mechanisms of coordination between the agents of the abovementioned Science, Technology and Innovation Spanish System.

The EECTI establishes priority areas that cover the entire process of development and application of scientific and technological research 'from idea to the market'. Its objectives include guidance on scientific and technical research, technological development and innovation concerning major challenges for Spanish society which, like health, ageing, the application and upholding of the principles of inclusion of the most fragile segments of our society, environmental sustainability, resilience to climate change, energy supply, biodiversity, the transformation of our political and social systems and the safety of our citizens are, essentially, great global challenges for society.

One of the objectives of the EECTI is to guide RIC activities, including fundamental scientific and technical research, technological development and innovation, towards eight major areas that involve important markets for the development of new products and services: 1. Health, demographic change and well-being; 2. Food safety and quality; productive and sustainable agricultural activity; sustainability of natural resources, marine and maritime research; 3. Safe, sustainable and clean energy; 4. Intelligent, sustainable and integrated transport; 5. Action on climate change and efficiency in the use of resources and raw materials; 6. Social change and innovation; 7. Digital economy and society; 8. Security, protection and defence.

The State plans for scientific and technical research and innovation, prepared by the Ministry, with the contributions of public research centres, universities, technology centres, business associations, technology platforms and experts from the scientific, technical and business community, are the specific articulation of the abovementioned Strategy 2013-2020. The 2017-2020 Plan (PEICTI 2017-2020) approved by the Council of Ministers in December 2017, as well as the plan corresponding to the 2013-2016 period, is made up of four state programmes that correspond to the general objectives established in the Strategy: the promotion of talent and employability; the generation of knowledge and strengthening of the system; business leadership in RDI; and RDI aimed at the challenges facing society.

Finally, within the framework of the European Union's Partnership Agreement with Spain 2014-2020, the Spanish Strategy for Science, Technology and Innovation and the State plans for scientific and technical research and innovation jointly define the national framework for smart specialisation (RIS3) on which the Autonomous Communities base their research and innovation strategies for smart specialisation.

The Spanish Strategy for Science, Technology and Innovation 2013-2020 is supplemented with sectoral policies. In this regard, coordination is established with the Spanish Strategy for climate change and clean energy, which seeks to meet Spain's commitments on climate change and promoting clean energies while improving social welfare, economic growth and environmental protection.

Spain is undergoing a cost-effective energy transformation that allows it to comply with the European objectives of GHG emission reduction and decarbonisation of the economy. This is in accordance with the provisions of the Europe 2020 Strategy and its flagship initiative 'A resource-efficient Europe', which ensures supply and economic growth in Europe, with research and innovation as one of its fundamental pillars.

The **Strategic Energy Technology Plan** (SET Plan) plays a key role in all this process. In September 2015, the Communication from the Commission **'Towards an Integrated Strategic Energy Technology (SET)-Plan: Accelerating the European Energy System Transformation'** proposed 10 key actions in line with the priorities of the Energy Union and its 5th pillar in terms of research, innovation and competitiveness. The proposal sought a definitive change in the concept of the European energy system, proposing an integrated system that would move beyond the silos of energy technologies which had been the focus previously.

Cooperation with other Member States is also carried out through transnational technology cooperation programmes:

- Eureka, and bilateral cooperation programmes, in which the participation of Spanish companies is financed by the Centre for Industrial and Technological Development (CDTI), by means of loans with a non-reimbursable tranche through a non-competitive call that is open all year round.
- Eurostars, for SMEs that are strong on R&I. In this case, CDTI provides funding via subsidies in a competitive call for applications. Closing dates established.
- ERANETs-cofund, with the possibility of participation by different types of entities, which will be funded through subsidies – competitive calls for application. Closing dates established.
- Horizon 2020, open to participation by all types of entities. Annual calls with established closing dates, competitive calls and funding via subsidies.

Research and innovation policies are proposed and implemented by the units responsible for funding activities proposed by the Ministry. The Spanish Strategy for Science, Technology and Innovation and its State Plans for RDI are used in implementing them. These include activities such as:

The **State Research Agency** (Agencia Estatal de Investigación - AEI), which is a unit of the State Secretariat for Universities, Research, Development and Innovation of the Ministry of Science, Innovation and Universities, created by means of Royal Decree 1067/2015 of 27 November 2015 with the aim of being the instrument used to modernise public management of the state R&D policies in Spain, is responsible for the financing, evaluation, granting and monitoring of scientific and technical research activities. The AEI manages the following programmes of the State Plan: the State programme for the promotion of talent and its employability; the State programme for the generation of knowledge and institution-building and technological strengthening; and the State Programme of RIC aimed at societal challenges.

The **Centre for Technological and Industrial Development** (Centro para el Desarrollo Tecnológico e Industrial - CDTI), a Public Business Entity which is a unit of the State Secretariat for Universities, Research, Development and Innovation of MITECO, aims to increase the competitiveness of Spanish companies by improving their technological level. It carries out financing activities of business RIC projects (State Programme of Business Leadership), as well as projects to manage and promote the Spanish participation in international programmes of technological cooperation and support for the creation and consolidation of technology-based companies.

In addition, the main entities focused on executing the actions subsidised by the AEI are the Public Research Organisations, such as the **Scientific and Research Centre (Centro Superior de Investigaciones Científicas - CSIC) or the Centre for Energy and Technological Research (Centro de Investigaciones Energéticas y Tecnológicas - CIEMAT)**, directly attached to the General Secretariat of Scientific Policy Coordination of the Ministry of Science, Innovation and Universities.

Among the actions of the State Research Agency, **Technological Platforms** stand out. These are forums for teamwork led by the industry, which integrate all the agents of the Science-Technology-Innovation system (companies, technology centres, public research organisations, universities, R&I centres, associations, foundations, etc.), with the main objective of defining the short, medium and long-term vision of the sector and of establishing a strategic route in RIC. Their objectives include:

- encouraging competitiveness, sustainability and growth of the industrial sector and of the Spanish scientific-technological sector;
- being a mechanism of RIC transmission of to the national and international market;
- directing the generation of employment and the creation of innovative companies through projects and actions.

Finally, we should mention the **ALINNE** initiative, which is non-profit and open to all agents in the RIC energy value chain. This is an initiative that was created to combine and coordinate efforts among all the agents in the RIC energy value chain, allowing a response to the main challenges for RIC policy in the energy sector, thereby contributing to the definition of work guidelines at national level and the definition of a European position.

2 GENERAL AND SPECIFIC NATIONAL OBJECTIVES

2.1 DIMENSION DECARBONISATION

As indicated, Spain's long-term objective for 2050 is to become a **carbon-neutral** country. For this purpose a binding objective was established to mitigate at least 90 % of gross GHG emissions compared to the reference year 1990. In this sense, the objective of emissions mitigation for the year 2030 is at least 20 % when compared to 1990. As a result of the measures mentioned in this Plan, there will be a change from **340.2 MtCO$_2$-eq emitted in 2017 to 226.7 MtCO$_2$-eq in the year 2030**, which means that approximately one third of the current emissions will be removed in the next twelve years.

To be specific, in the decade between 2021 and 2030 and as a result of the application of the measures of this National Plan (see chapter 3), the gross total emissions will decrease from 327.4 MtCO$_2$-eq predicted for the year 2020 to 226.7 MtCO$_2$-eq in 2030. The sectors of the economy that will reduce their emissions most in absolute terms during that period are the following:

- electricity generation, 44 MtCO$_2$-eq
- mobility and transport, 28 MtCO$_2$-eq
- residential, commercial and institutional sectors, 7 MtCO$_2$-eq.

Table 2.1. Evolution of emissions (thousands of tonnes of CO$_2$ equivalent)

Years	1990	2005	2015	2020*	2025*	2030*
Transport	59 199	102 310	83 197	85 722	74 638	57 695
Electricity generation	65 864	112 623	74 051	63 518	27 203	19 650
Industrial sector (combustion processes)	45 099	68 598	40 462	40 499	37 246	33 530
Industrial sector (emissions from processes)	28 559	31 992	21 036	21 509	22 026	22 429
Residential, commercial and institutional sectors	17 571	31 124	28 135	26 558	23 300	19 432
Livestock farming	21 885	25 726	22 854	23 247	21 216	19 184
Crops	12 275	10 868	11 679	11 382	11 086	10 791
Waste	9 825	13 389	14 375	13 657	11 898	9 650
Refining industry	10 878	13 078	11 560	12 247	11 607	10 968
Other energy industries	2 161	1 020	782	721	568	543
Other sectors	9 082	11 729	11 991	14 169	13 701	13 259
Fugitive emissions	3 837	3 386	4 455	4 715	4 419	4 254
Product use	1 358	1 762	1 146	1 231	1 283	1 316
Fluorinated gases	64	11 465	10 086	8 267	6 152	4 037
Total	287 656	439 070	335 809	327 443	266 343	226 737

*The data for 2020, 2025 and 2030 are estimates of the Target Scenario of the INECP.

Source: Ministry for Ecological Transition, 2019.

The planned decarbonisation in the electricity sector reduces emissions by **44 MTCO$_2$** equivalent. This reduction is the result, firstly, of **the substantial loss of significance of coal in electricity generation in the period of the Plan.** However, it is important to point out that it is very possible that nine of the fifteen coal-fired power plants currently in existence in 2019 will not be operational at the beginning of the Plan in 2021. This will be as a result of the decision adopted by the companies owning them not to make investments corresponding to the requirements of the European Union regarding polluting emissions. This means that it is expected that at the beginning of the Plan only six coal-fired thermal power stations will still be active.

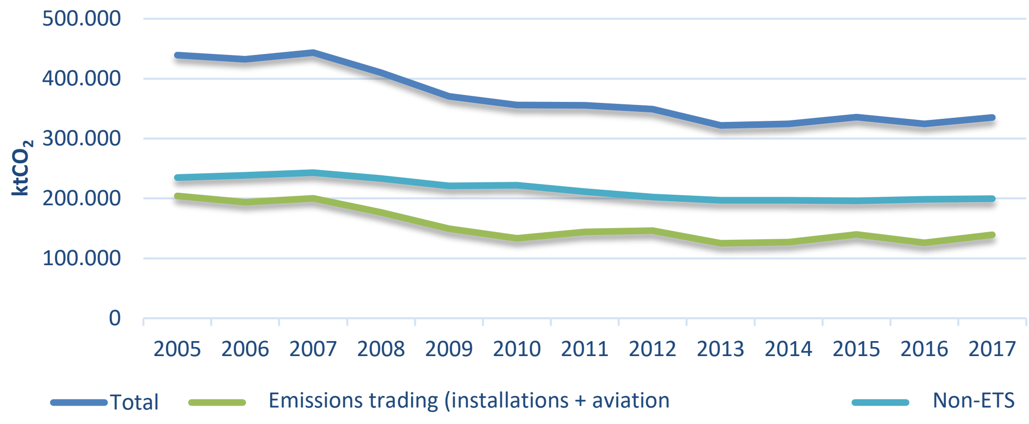
According to the Plan's forecasts, by 2030, coal-fired thermal power stations **will no longer be competitive** given that the expected price per tonne of CO_2 in the European system for buying and selling emissions will be EUR 35/t. At the same time, the disruptive reduction in the costs of electricity generation renewables is altering the profitability assumptions for the different technologies significantly. This makes the disappearance of electricity generation from coal virtually inevitable by 2030. In any case, we cannot rule out that where investments have been made to comply with the EU framework, part of the installed capacity will be maintained. For reasons of accounting prudence, this fact is reflected in the table relating to the evolution of installed capacity of electricity for the year 2030 (Table 2.2). In any case, the transition in the sector will need to be accompanied by support measures aimed at the affected regions in order to ensure that the process is carried out in a fair and supportive manner.

Secondly, the decarbonisation of the electricity sector will be the result of the significant penetration of renewable technologies in the Plan, which will replace generation from fossil fuels on a large scale. Renewable electricity generation in 2030 will be **74 % of the total** consistent with a path towards a **100 % renewable electricity sector in 2050**.

In the mobility-transport sector, the planned reduction is **28 Mt CO_2-eq**. Above all, this result is a consequence of the important modal shift from the conventional combustion vehicle to public transport, shared and non-emitting modes, and as a result of the generalised **delimitation of central areas in cities with more than 50 000 inhabitants starting from 2023** where we plan to limit access to the most emitting and polluting vehicles. As a consequence of the implementation of this measure we plan that **35 % of passenger-kilometres that are currently carried out in conventional vehicles will shift to non-emitting modalities by 2030.** The result of the significant presence of electric vehicles is also planned by 2030: **5 million units**, including cars, vans, motorcycles and buses.

The analysis of decarbonisation is also addressed from the perspective of emissions that are part of the EU ETS system and the non-ETS emissions (residential, transport, agriculture, waste, fluorinated gases and industry not subject to emissions trading). As already mentioned above, the gross GHG emissions for 2017 were 340.2 million tonnes of CO_2-eq. 39 % of these corresponded to sectors covered by emissions trading and 61 % to non-ETS sectors.

Figure 2.1. Spain GHG emissions (inventory) 2005-2017($ktCO_2$-eq)



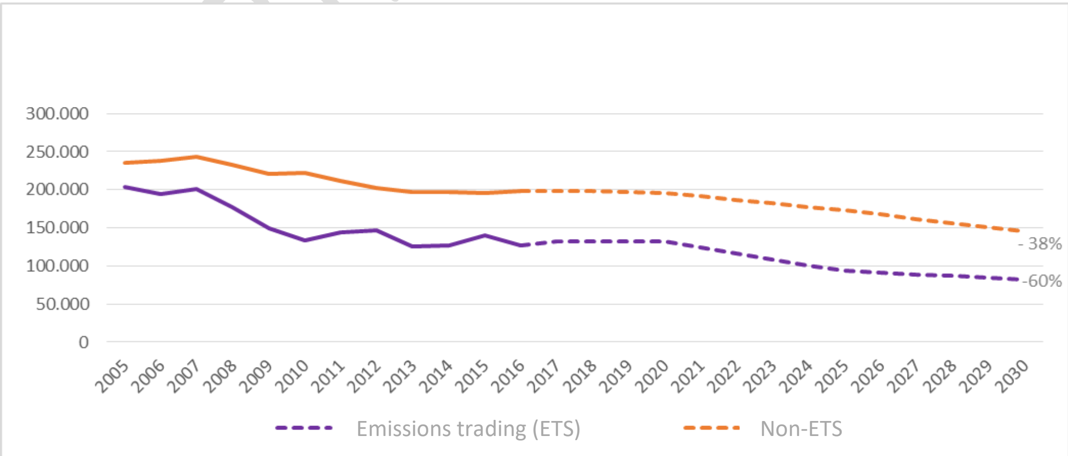
Source: Ministry for Ecological Transition, 2019.

The goals established in terms of GHG reduction in this National Plan not only meet the binding objectives set out in EU regulations, but also increase ambition, thereby contributing to the achievement of the goal of reducing emissions throughout the European Union, as well as international commitments which the European Union and Spain have undertaken.

This Plan sets the minimum objective of GHG reduction of at least **20 % in 2030** when compared to 1990 levels.

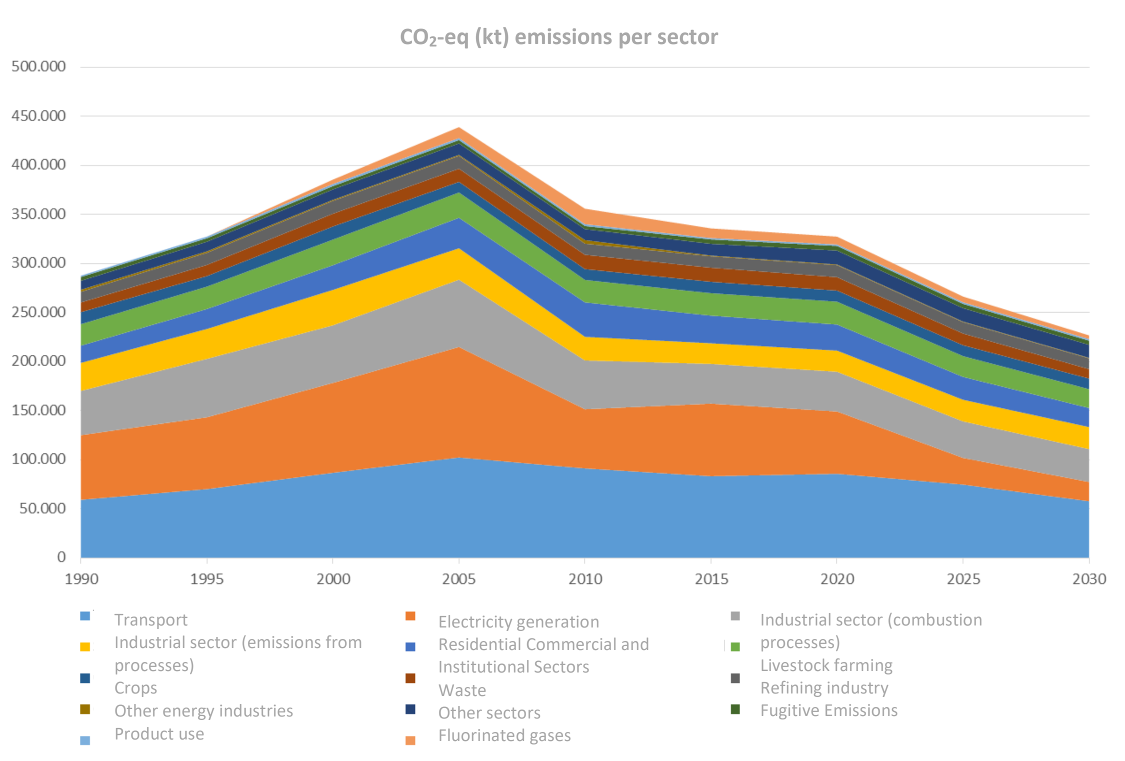
As already indicated above, the measures contemplated in this INECP **allow a 20 %emission reduction to be reached as a minimum when compared to 1990 levels.** The non-ETS sectors contribute with a 38 % reduction by 2030 with respect to 2005 levels, while the sectors subject to emissions trading contribute with a reduction of 60 % in 2030 when compared to 2005.

Figure 2.2. 2030 emissions objective. Historical series (2005 - 2016) and planned trajectory



Source: Ministry for Ecological Transition, 2019.

Figure 2.3. Emissions of CO_2-eq per sector. Historical and projection for 2030 (kt)



Source: Ministry for Ecological Transition, 2019.

Likewise, this Plan addresses the measures that are needed in order to comply with Spain's commitments under Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework. In this framework, the necessary measures will be implemented to ensure that during the periods between 2021 and 2025 and between 2026 and 2030, the total emissions of this sector do not exceed the total removals of the Spanish territory in the accounting categories of afforested lands , deforested lands, managed cropland, managed grassland, managed forest land and managed wetland. **This means that Spain must guarantee that during the 2021-2030 period, the emissions of this sector do not exceed the removals.**

According to the accounts established in the aforementioned Regulation, the contribution of the measures to the generation of removals in the LULUCF sector will depend on the forest reference level, which is currently in the calculation phase, and it must be sent to the European Commission not later than 31 December 2019 (for the period between 2021 to 2025). For this reason, the present draft does not include the quantitative contributions planned for the LULUCF sector, but these will be incorporated into the final INECP 2021-2030 once the forest reference level is defined. In any case, **Spain will be able to use up to 29.1 $MtCO_2$ of net removals from the LULUCF sector during the 2021-2030 period in order to meet the objectives in non-ETS sectors.**

Also, progress towards high standards in the regulatory or fiscal field in Europe requires the establishment of measures, in particular as regards imports, ensuring that there will be no displacement of emissions to other regions (carbon leakage) as well as a level of fair competition for companies on a global level.

In terms of adaptation, Spain will prepare a new **National Plan for Adaptation to Climate Change (Plan nacional de adaptación al cambio climático - PNACC)** as a basic planning tool in order to promote coordinated and coherent action against the effects of climate change in Spain. This new PNACC will define the objectives, criteria, areas of application and actions to promote resilience and adaptation to climate change. During the 2021-2030 period, the new PNACC will specifically cover the following objectives as a minimum:

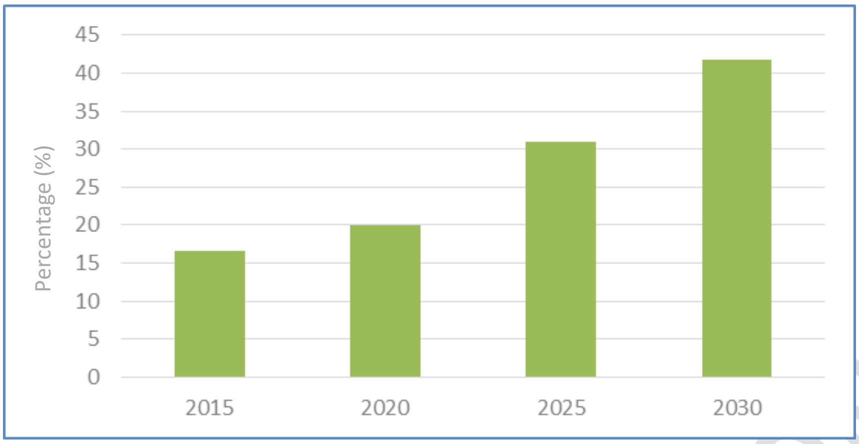
- periodically update regionalised climate change projections for Spain throughout the 21st century and promote the periodic updating of hydrological and oceanographic scenarios on the basis of IPCC reports;
- make those projections available to interested parties while providing tools for consulting and viewing climate projections;
- promote the generation of knowledge regarding impacts and risks derived from climate change and the identification of adaptation measures to minimise them;
- promote access to available knowledge regarding impacts and risks derived from climate change as well as mitigation and adaptation measures aimed at limiting them, facilitating training and education on the subject;
- continue promoting the integration of adaptation to climate change in the regulations and planning of the different sectors;
- facilitate the coordination of actions between the different Public Administrations (national, regional and local) while promoting complementarity and efficient use of public resources;
- encourage the active involvement of Spanish society and mobilise key actors in the development of adaptive responses to climate change.

2.1.1 Electrification and decarbonisation of the energy system

Three of every four tonnes of GHG originate in the energy system, so **their decarbonisation is the cornerstone on which energy transition must take place.** In order to achieve this objective, it will be necessary to electrify a significant part of the thermal demand and the demand for transport. Furthermore, a transition from fossil fuels to renewable energies is necessary.

As a result of the measures contemplated in this Plan which are aimed at reducing the use of fossil fuels and the promotion of renewable energy sources in the three uses of energy – transport, heating and cooling and electricity – **renewables reach 42 % of the total energy end-use,** above the common goal of 32 % set by the European Union.

Figure 2.4. Contribution of renewable energies on final energy consumption with the planned set of measures



Source: Ministry for Ecological Transition, 2019.

Transport	**As a result of the measures adopted in this Plan, 22 % of renewables is achieved in transport via electrification and biofuels, above the 14 % required by the European Union in 2030.**

The main aspects of decarbonisation in the transport sector are the modal shift, the rapid deployment of electric mobility and a boost to the manufacture and use of advanced biofuels. The first two aspects are included in this Plan as energy efficiency measures.

Heating and cooling	**Electrification and growth of the use of thermal renewables.**

Currently, in the heating and cooling sector, there are no disruptive technologies that lead to decarbonisation. In this case, innovation comes from promoting new players and investment models. In this sense, the National Plan focuses on renewable energy communities proposing regulatory development that allows them to exercise their right to generate, consume and sell renewable energy. It also focuses on the promotion of a set of administrative and economic measures. An increase in electricity use for the generation of heat is also proposed.

However, according to the Plan's forecasts and despite this limitation, the advance of renewables in the 2021-2030 period is very relevant in almost all sectors of the economy, as can be seen from the following data:

- electricity generation (includes electric vehicles): increases from 9 793 to 20 998 ktoe;
- heat pumps: increases from 650 to 4 076 ktoe;
- residential: increases from 2 607 to 3 123 ktoe;
- industry: increases from 1 721 to 2 585 ktoe;
- Transport (biofuels): reduces from 2 283 to 1 568 ktoe.
- services and other: increases from 355 to 596 ktoe;
- agriculture: increases from 94 to 278 ktoe.

Ultimately, the presence of renewables in energy end-use increases from **20 % foreseen for the year 2020 to 42 % in 2030.**

The transition to a decarbonised electrical system involves the extensive incorporation of renewable sources.	
Generation of electricity	• **By means of the measures in the Plan, 74 % of generation from renewables will be achieved in the electric 'mix' in 2030.** • **Difficulty to compete for fossil fuels in a European environment with the price of EUR 35 per tonne of CO_2 in 2030.**

The achievement of ambitious targets in the field of electricity from renewable energy sources involves a three-pronged strategy: the promotion of large generation projects, the deployment of self-consumption and measures to integrate renewables in the system and the electricity market.

At an international level, the large-scale development of renewable energies in the last decade led to a disruptive reduction in their relative cost to the extent that, currently, in the vast majority of situations, renewable sources - mainly wind power and solar - generate the most cost-efficient electricity when it comes to developing new capacity.

The Plan foresees that the total installed capacity in the electricity sector will be of 157 GW in 2030. In view of the significant deployment of renewable technologies planned for the electricity sector, the INECP 2021-2030 considers **tenders to be the main tool for the development of these technologies**, in accordance with Directive 2018/2001 on the promotion of the use of energy from renewable sources. The design of the tenders is based on the predictability and stability of the revenues in order to facilitate the decision of investment and its financing and it should prioritise those installations that facilitate a more efficient energy transition. In any case, the design of the compensation system should minimise the insecurity that may arise from its large-scale development to prevent it from becoming an increase in the price of energy, due to:

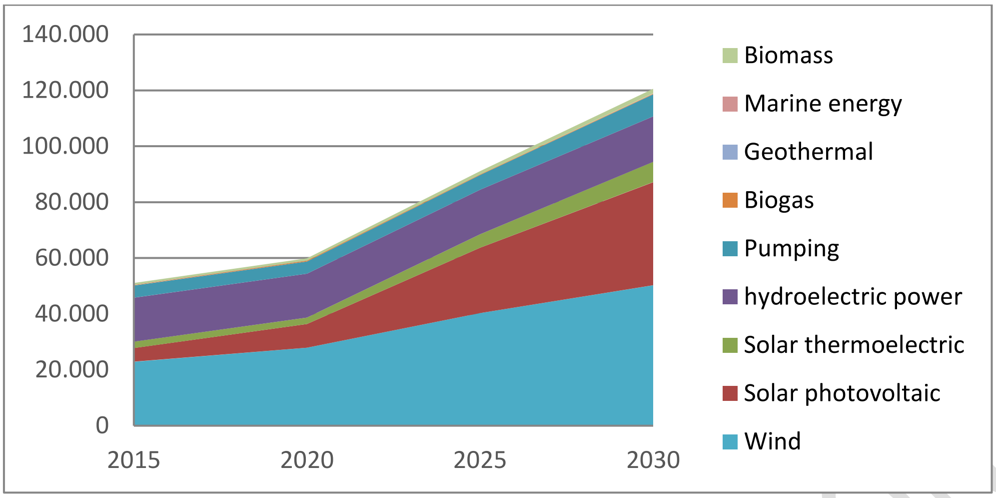
- a depression in the wholesale market prices;
- the existence of discharge during times of high renewable generation;
- an increase in social opposition, due to a high concentration of projects in larger resource locations, coupled with an inefficient distribution of co-benefits.

In order to achieve these objectives in the development of renewable energy technologies, it is very important to work together with the Autonomous Communities and the economic and social agents in order to identify and jointly eliminate the obstacles of renewable energies to implantation on the territory and therefore guarantee viable and efficient development.

Massive deployment of renewable self-consumption is also planned. This is facilitated by the existence of renewable resources in the national territory, the modularity of installations and cost-reduction, which in some cases led to self-generation being cheaper than final consumer fees (network parity).

The Target Scenario proposed by the Plan represents a considerable increase in renewable generation capacity when compared to the current situation.

Figure 2.5. Installed capacity of renewable technologies (MW)



Source: Ministry for Ecological Transition, 2019.

Table 2.2. Evolution of the installed capacity of electricity (MW)

Generation system in the Target Scenario (MW)				
Year	**2015**	**2020**	**2025**	**2030**
Wind	22 925	27 968	40 258	50 258
Solar photovoltaic	4 854	8 409	23 404	36 882
Solar thermoelectric	2 300	2 303	4 803	7 303
Hydroelectric power	14 104	14 109	14 359	14 609
Mixed Pumping	2 687	2 687	2 687	2 687
Pure Pumping	3 337	3 337	4 212	6 837
Biogas	223	235	235	235
Geothermal	0	0	15	30
Marine energy	0	0	25	50
Biomass	677	877	1 077	1 677
Coal	11 311	10 524	4 532	0 – 1 300
Combined cycle	27 531	27 146	27 146	27 146
Coal cogeneration	44	44	0	0
Gas cogeneration	4 055	4 001	3 373	3 000
Petroleum products cogeneration	585	570	400	230
Fuel/Gas	2 790	2 790	2 441	2 093
Renewables cogeneration	535	491	491	491
Cogeneration with waste	30	28	28	24
Municipal solid waste	234	234	234	234
Nuclear	7 399	7 399	7 399	3 181
Total	105 621	113 151	137 117	156 965

*The data for 2020, 2025 and 2030 are estimates of the Target Scenario of the INECP.

Source: Ministry for Ecological Transition, 2019.

The total renewable installed capacity for 2025 and 2030 is provided in the INECP. However, the path established for the achievement of the objectives set for 2030 is based on the principles of technological neutrality and cost efficiency. The energy model carried out to achieve the objectives of the INECP, takes into account the foreseeable development of the benefits and costs of all technologies over time. It is also based on the premise of the cost-efficient maximisation of the trajectories of deployment of the different technologies respecting the boundary conditions established with the objective of fulfilling the objectives of the five dimensions of the INECP (refer to annexes: 0, A and B).

In any case, specific distribution by means of renewable technologies between 2021 and 2030 will depend on their relative costs, as well as on the viability and flexibility of their implementation. Therefore their relative weight may vary, within some margins, with respect to the figures presented here. In summary, the Plan proposes a balanced and diverse development of the renewable generation stock, providing medium-term visibility for each technology.

2.1.2 From generation to demand management and storage

The massive development of renewable generation makes it necessary to plan its integration into the system. The old paradigm of base and peak generation becomes a new one of variability versus flexibility. The National Plan guarantees flexibility of the system allowing demand and storage management to contribute to the security and quality of supply, reducing the dependence of thermal power plants on fossil fuels as a back-up mechanism.

Generation of electricity	• **Both the large-scale development of storage and the demand management to favour the integration of renewables in the electricity sector are promoted.**

The **demand management** of electricity is the series of actions performed directly or indirectly by Public Administrations, energy distribution and marketing companies, energy services companies and independent aggregators, on the energy demand of consumers in order to modify the configuration over time or the magnitude of their level of energy demand. This contributes to cost reduction, a lower impact on the environment, an improvement in the competitiveness of consumers and efficiency in the use of generation, transmission and distribution systems.

The instruments to promote demand management can be economic incentives, the introduction of more efficient technologies and techniques, or influence on the habits of consumers. For this reason, we propose the development of the figure of the aggregator and the demand management plans through which different players can participate in fundamental services to the system.

With regard to **storage**, the National Plan foresees that by 2030 there will be an additional capacity of **3.5 GW** pumps for storage and **2.5 GW** of batteries. The precise composition and operation of these will be developed according to the technological evolution and availability. In addition, the application of new pumping operation procedures will be taken into account.

2.1.3 The role of the citizens in energy transition

At the end of 2016, the so-called 'Winter Package' of the European Commission proposed to place citizens at the centre of the energy transition. In this sense, Directive 2018/2001 on the promotion of the use of energy from renewable sources provides in its articles that the Member States must **guarantee that consumers have the right to produce, consume, store and sell their own renewable energy**, and evaluate both the obstacles and potential of development of the **renewable energy communities**.

The proliferation of renewable projects and their possible concentration in locations that have the best resources will only be possible with high levels of social acceptance. For this purpose, it is necessary that the citizens perceive the benefits of the deployment of renewable energies directly. In this sense, it is necessary to apply the social perspective transversally in the set of proposed measures so that they reach society as a whole, including promoting a proactive role of citizens in the energy transition.

Also, the transition towards a model based on renewable energies allows democratisation of the energy system and offers new opportunities to citizens, corporations and local authorities, **who were only consumers in the conventional model and today can be proactive agents.** This participation of new players and the development of self-consumption favours new sources of investment in decarbonisation, better integration and acceptance of energy infrastructures in the territory, the reduction of losses due to transport and distribution, the use of urban space for renewable generation, greater societal energy awareness and the emergence of new business models.

The **right of access to energy** is also another fundamental aspect of the change in the energy model. In this sense, they highlight the potential of energy upgrading of buildings and self-consumption systems – in particular shared self-consumption – in order to mitigate situations of vulnerability and energy poverty.

They also add that knowledge and information are the basis for greater involvement of citizens in the energy field. For this reason, outreach programmes are planned in order to allow the understanding of the energy system to all citizens, as well as the right of access to their own energy consumption data.

The Integrated National Energy and Climate Plan 2021-2030 proposes instruments and measures to facilitate and reinforce the role of local energy communities and the emergence of new players in the energy transition, as well as guaranteeing the right of access to energy.

Finally, we note that the starting point of the actions of INECP 2021-2030 in Spain, with regard to electricity generation, is **Royal Decree-Law 15/2018** on urgent measures for the energy transition and protection of consumers, which recognises the right to shared self-consumption and introduces the principle of administrative and technical simplification in its development.

2.2 DIMENSION ENERGY EFFICIENCY

2.2.1 National energy efficiency objective in 2030

The Energy Efficiency Directive (Directive 2012/27/EU of 25 October 2012 on energy efficiency and its subsequent amendment) establishes a common framework of measures for the promotion of energy efficiency within the European Union with the objective of ensuring the achievement of the main objective of improving efficiency by 20 % in 2020 and 32.5 % in 2030.

Within this common regulatory framework, it is up to each Member State to set an indicative national objective for energy efficiency based on primary or final energy consumption, on primary or final energy savings or on energy intensity. In a consistent manner with previous plans, Spain has chosen to set the target for energy efficiency by 2030 in terms of primary energy consumption.

In this way, this INECP adopts the objective approved by the European Union of improving energy efficiency by 32.5 % in 2030, although with the measures put in place and in accordance with the modelling exercise carried out, **it is expected to reach an improvement of 39.6 %[24] in 2030**. This will result in primary energy consumption (not including non-energy uses) of **98.2 Mtoe** during that year.

While the European Union's objective is to improve energy efficiency by 32.5 % for 2030 with respect to the PRIMES scenario (refer to figure 2.6), as a result of the measures provided for in this Plan, an **improvement of 39.6% in efficiency** is expected in Spain with respect to the trajectory of the abovementioned PRIMES baseline scenario.

As a consequence of the objective established for 2030, Spain reviewed and updated its objective of improving energy efficiency by 2020 with respect to the objective in the National Action Plan for Energy Efficiency 2017-2020.

In that Plan, the objective for 2020 meant that primary energy consumption should not exceed 122.6 Mtoe. This involved a 24.7 % improvement in energy efficiency. In line with this INECP 2021-2030, the 2020 target is now formulated as an improvement of 26.1 %, which means that 120.3 Mtoe should not be exceeded in terms of primary energy consumption (discounted non-energy uses).

[24] With reference to the projections for 2030 of the PRIMES Model (2007) of the European Commission, which serves as a reference in the Energy Efficiency Directive to set the indicative objective of primary energy consumption of the European Union in 2030.

Table 2.3. Evolution of primary energy consumption, including non-energy uses (ktoe)

Year	2015	2020*	2025*	2030*
Coal	13 714	11 337	4 362	1 128
Oil and its derivatives	52 949	50 999	45 453	38 149
Natural gas	24 538	26 498	23 501	24 531
Nuclear energy	14 927	15 031	15 031	6 462
Renewable energy	16 646	20 856	28 093	35 066
Industrial waste		238	282	341
MSW (non-renewable)	252	105	123	190
Electricity	-11	-335	-1 351	-2 731
Total	123 015	124 727	115 494	103 136

*The data for 2020, 2025 and 2030 are estimates of the Target Scenario of the INECP.

Source: Ministry for Ecological Transition, 2019.

Spain has already embarked on the path towards decarbonisation with the elimination of obstacles to self-consumption and the approval of regulatory and fiscal measures in order to accelerate the transition towards a low carbon economy is proposed. The competition of all the territorial administrations will allow progress in this process of energy transition in which the Autonomous Communities and the local authorities will play a fundamental role. The model of distribution of competences in Spain, where the General State Administration, the Autonomous Communities and the local authorities share competences in different areas, imposes the obligation to make a coordination effort, particularly in certain areas of paramount importance such as urbanism and mobility, in order to transform our cities.

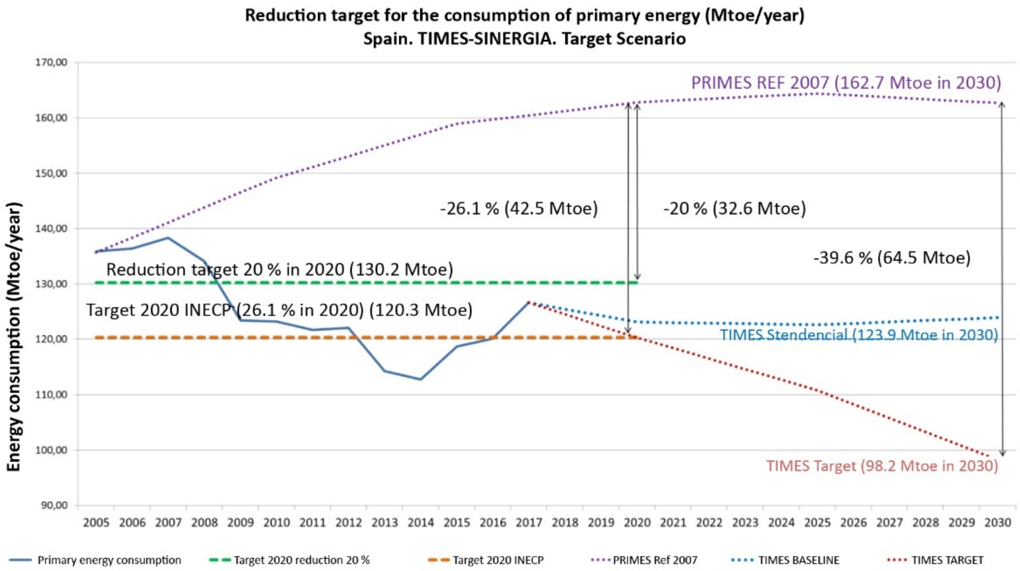
In this regard, this INECP intends to act on the modal shift, the reduction of traffic and electrification in terms of energy consumption in the transport sector. It also intends to act on the energy upgrading of the existing building stock, so that cities and their governments must be very important active agents of change[25].

The reduction in primary energy consumption proposed in this INECP was equivalent to 1.9 % yearly since 2017, which when linked to an expected increase in GDP in the same period of around 1.7 % will result in **an improvement of the primary energy intensity of the economy of 3.6 % per year until 2030.** This improvement in primary intensity is the result not only of the series of energy efficiency measures in energy end-use, but also of energy efficiency improvements in transport and energy distribution, as well as greater penetration of renewable energy in electricity generation plant.

As a result of the policies and measures in this Plan, the final energy consumption will be reduced at a year-on-year rate of 1 % between 2017 and 2030, **up to 74.4 Mtoe, which represents an improvement in the final energy intensity of around 2.6 % per year.**

[25] Similarly to decarbonisation technologies, the energy model carried out to achieve the objectives of the INECP, takes into account the foreseeable development of the benefits and costs of all efficiency technologies over time. It is also based on the premise of the cost-efficient maximisation of the trajectories of deployment of the different technologies while respecting the boundary conditions established with the objective of fulfilling the objectives of the five dimensions of the INECP.

Figure 2.6. Reduction objective for the consumption of primary energy (Mtoe/year)



Source: Ministry for Ecological Transition, 2019.

2.2.2 Accumulated objective of saving of final energy 2030

The Energy Efficiency Directive obliges the Member States to credit the achievement of an objective of cumulative energy savings in the period, firstly, between 1 January 2014 and 31 December 2020, and secondly, between 1 January 2021 and 31 December 2030.

This cumulative objective of final energy has been calculated pursuant to the provisions of Article 7 of Directive 2012/27/EU. For the first period it amounts to 15 979 ktoe, which is equivalent to 571 ktoe/year of new and additional savings of final energy, assuming that a linear distribution of the objective will be applied throughout that period. In addition, the accumulated objective of saving of final energy for the second period amounts to **36 809 ktoe**, which is equivalent to the achievement of new and additional savings of 669 ktoe/year every year from 1 January 2021 to 31 December 2030.

The objective of accumulated savings of final energy of this Plan is equivalent to 36 809 ktoe, calculated from 1 January 2021 to 31 December 2030.
This cumulative objective of savings of final energy means the achievement of new and additional savings each year amounting to 669 ktoe/year, as a result of the application of the provisions of Article 7 of the Energy Efficiency Directive —savings equivalent to 0.8 % of the average annual final consumption of the last three years prior to 1 January 2019.

The main difference between the calculation of the objective for the first and the second period is the fact that 0.8 % must be applied to the total consumption of final energy without excluding the consumption of the transport sector and without the possibility of applying the flexibility mechanisms previously provided in Article 7(2). As a consequence of the modification of the calculation mechanism of the objective, the Energy Efficiency Directive (in its revision up to 2030) has increased the level of ambition by 22 %for Spain when compared to the previous Directive[26].

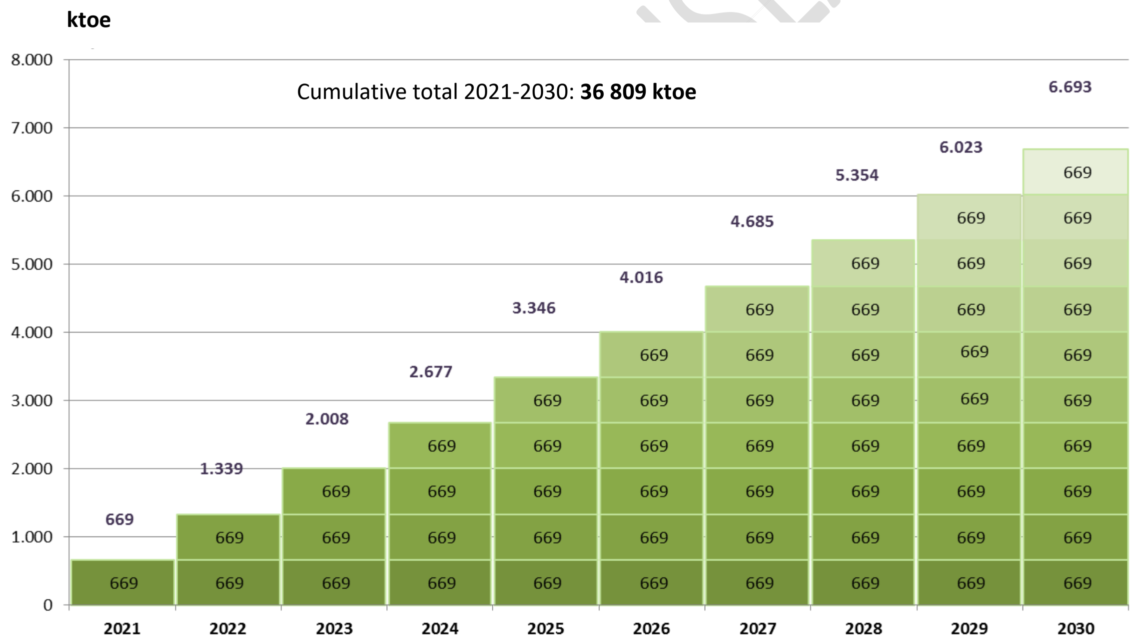
Table 2.4. Evolution of final energy consumption, including non-energy uses (ktoe)

Year	2015	2020*	2025*	2030*
Coal	1 522	1 239	1 090	1 040
Petroleum products	40 330	39 690	34 528	27 653
Natural gas	13 139	16 218	16 701	15 677
Electricity	19 951	20 105	20 537	21 579
Renewable energy	5 287	7 073	7 702	8 073
Other non-renewables	2	263	306	362
Non-energy	4 311	4 405	4 681	4 894
Total	84 542	88 994	85 544	79 279

*The data for 2020, 2025 and 2030 are estimates of the Target Scenario of the INECP.

Source: Ministry for Ecological Transition, 2019.

Figure 2.7. Accumulated objective of saving of final energy: 2021-2030



Source: Ministry for Ecological Transition, 2019.

2.2.3 Long-term strategy for building renovation

The long-term strategy for building renovation provided in Article 4 of the Energy Efficiency Directive was published in 2014 by the Ministry of Development ('2014 ERESEE. Long-term strategy for energy upgrading in the building sector in Spain27) and, updated, in accordance with the provisions of the same article, in 2017: '2017 ERESEE. Update of the Long-term

[26] The increase in the level of ambition of Article 7 of the Energy Efficiency Directive has been especially relevant for those countries where the transport sector plays a greater part in the structure of final energy consumption.

[27] Available on: https://www.fomento.gob.es/recursos_mfom/pdf/39711141-E3BB-49C4-A759-4F5C6B987766/130069/2014_article4_es_spain.pdf.

strategy for energy upgrading in the building sector in Spain28. The update carried out by the 2017 ERESEE had a qualitative approach, focusing on the analysis of the impact of measures already adopted to boost energy efficiency in buildings.

In May 2018, Directive 2018/844/EU substantially amended Directives 2010/31/EU and 2012/27/EU, introducing a new Article 2a in Directive 2010/31/EU on the long-term strategy to support the renovation of the national stock of residential and non-residential buildings, both public and private. **A new objective has been established now in order to make the building stock highly energy efficient and decarbonised before 2050, facilitating the cost-effective transformation of existing buildings into nearly zero-energy buildings.**

These decarbonisation objectives of the building stock by 2050 are taken up by this INECP and will be provided in the 2020 ERESEE, which will be presented before 10 March 2020 and which will include intermediate objectives for 2030 and 2040.

The objectives for the energy upgrading of buildings up to 2030 are summarised in this Plan in measures 6 and 8, provided in section 3.2.1. in Chapter 3 ('Policies and measures') of this Plan.

Objectives regarding the energy upgrading of buildings	• **Improvement of energy efficiency (thermal envelope) throughout the decade for a total of 1 200 000 homes** • **Improvement of energy efficiency (renovation of thermal heating and DWH installations) of 300 000 homes/year**

2.2.4 Energy efficiency objective of public buildings

The Energy Efficiency Directive establishes that Member States shall draw up and publish an energy inventory[29] of buildings with heating and/or cooling systems owned by the General State Administration. On the basis of this inventory, Member States must **renovate 3 % of the building floor area each year**, so that these buildings comply with the minimum energy performance requirements established in Article 4 of the Directive on the Energy Performance of Buildings (Directive 2010/31/EU as amended by Directive 2018/844/EU).

According to the inventory which was updated and published in December 2017, the renovation objective for 2018 was 278 509 m². Energy renewal carried out between 2014 and 2017 affected a floor area of 1 240 035 m², which represents a compliance level of 105 % with the renovation objective established for that period.

The objective of renovating the building stock of the General State Administration required by the Energy Efficiency Directive is estimated at a total of 2 220 000 m² for the period covered by this INECP. This estimate does not only take into account the inventoried area, but also the evolution of the energy renovations carried out up to 2018 and the consequent reduction of the inefficient area of the General State Administration.

[28] Available on: https://www.fomento.gob.es/recursos_mfom/pdf/24003A4D-449E-4B93-8CA5-7217CFC61802/143398/20170524REVISIONESTRATEGIA.pdf.

[29] The inventory of buildings of the General State Administration is available at: https://www.mincotur.gob.es/energia/desarrollo/EficienciaEnergetica/directiva2012/Inventario2018/Inventario-2017-articulo_5.pdf

However, to ensure the level of ambition consistent with a decarbonised model in 2050, this Plan evaluates the savings that could be obtained from the renovation of 300 000 m^2/year in the General State Administration. The objective of renovating 3 % per year is also transposed to the other territorial Administrations.

Energy efficiency objectives for public buildings	• **Evaluation of the renovation of the public building stock of the General State Administration above the 3 % objective derived from Article 5 of the Energy Efficiency Directive (300 000 m^2/year)** • **Objective of renovating 3 % of the air-conditioned building floor area of the regional and local Administrations**

The savings achieved as a result of raising the ambition level in Article 5 of the Energy Efficiency Directive (which does not oblige government agencies at a regional and local level to achieve a specific percentage of annual renovation, or to prepare an inventory of public buildings) will allow the cumulative objective of saving final energy derived from Article 7 to be met. This was calculated at 36 809 ktoe for the whole period (669 ktoe/year, assuming that a uniform distribution of effort is carried out throughout the whole period).

2.3 DIMENSION ENERGY SECURITY

With reference to the changes in the energy mix that are proposed in this Plan, supplying safe, clean and efficient energy to the different consumer sectors will involve significant challenges and technological difficulties, which must be addressed from the different aspects that make up energy security:

1. reduction of energy dependency, especially the importing of fossil fuels;
2. diversification of energy and supply sources;
3. preparation to face limitations or interruptions in the supply of energy sources;
4. increase in the flexibility of the national energy system.

Regarding the first aspect, Spain had **an energy dependency ratio of 73 % in 2015 (see Table 2.5) and 74 % in 2017**, due to the prevalence of fossil fuels in the energy mix (coal, oil and gas), since Spain does not have significant volumes of domestic production of these fuels.

This dependence on primary energy has important economic repercussions. Therefore, in 2017, the balance of foreign trade in energy was unfavourable to Spain by EUR 20 billion. In this sense, the objective in this area of the National Plan has been to reduce the energy dependency ratio by reducing the importing of fossil fuels, especially coal and oil.

Table 2.5. Evolution of the primary energy dependency ratio (ktoe)

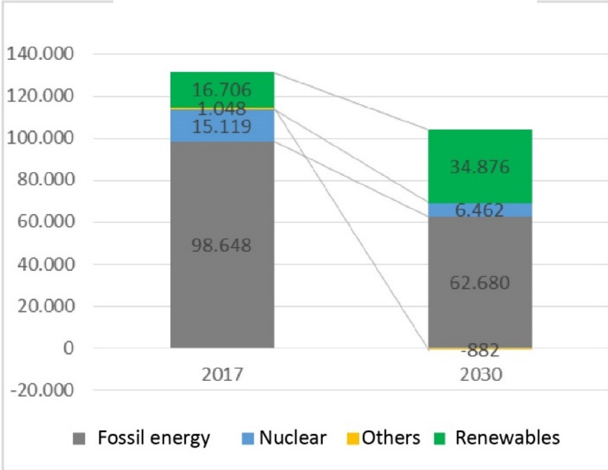
Years	2015	2020*	2025*	2030*
National production	**33 615 (27 %)**	**36 719 (29 %)**	**42 892 (37 %)**	**41 823 (41 %)**
Coal	1 246	1 110	0	0
Petroleum products	236	310	312	314
Natural gas	54	24	24	24
Nuclear	14 927	15 031	15 031	6 462
Renewable energy	16 899	19 797	26 998	34 301
Waste	252	448	528	721
Net imported/exported	**89 400 (73 %)**	**88 008 (71 %)**	**72 602 (63 %)**	**61 313 (59 %)**
Coal	12 468	10 227	4 362	1 128
Petroleum products	52 713	50 688	45 141	37 835
Natural gas	-24 484	26 474	23 478	24 507
Electricity	-11	-335	-1 351	-2 731
Renewable energy	-253	954	973	575
Total Primary Energy	**123 015**	**124 727**	**115 494**	**103 136**

*The data for 2020, 2025 and 2030 are estimates of the Target Scenario of the INECP.

Source: Ministry for Ecological Transition, 2019.

Energy dependence	**As a result of the measures provided for in this INECP 2021-2030, the energy dependency ratio of Spain decreases by 15 percentage points, going from 74 % in the present day (2017) to 59 % in 2030.**

Figure 2.8. ***Mix*** **of primary energy in Spain in 2017 and 2030 (ktoe)**



Source: Ministry for Ecological Transition, 2019.

Figure 2.9. Energy dependence in Spain in 2017 and 2030

Source: Ministry for Ecological Transition, 2019.

Regarding the diversification of energy sources and supply, the fundamental objective for Spain is to form an adequate mix of primary energy which includes technically and economically viable sources in the 2030 horizon in order to ensure the continuity of supply, as well as achieving the decarbonisation objectives set by this Plan.

Furthermore, their geographical origin must continue being diversified in order to reduce possible risks of interruption to supply as much as possible.

Diversification	Maximising the diversification of both energy sources and countries of origin of the supply

Thirdly, we must continue working on our preparation to face limitations or interruptions to the supply of energy sources, in order to increase the resilience of the national energy system.

Resilience	More in-depth preparation in order to face the limitations or interruptions to the supply of energy sources

Due to the low level of energy interconnections with the rest of the European continent, among other factors, Spain has a **solid preparation system to deal independently with limitations or interruptions to energy supply**, as well as plans for preparation for risks which are specific to the electricity sector.

We must remember, in this sense, that one of the main functions of the operators of the electricity and gas systems is to guarantee the continuity and security of supply and the correct management of the different networks, carrying out their functions in coordination with all the agents involved.

The objectives corresponding to the three levels of energy security that have been presented respond to needs from the energy supply side.

However, it is also necessary to take advantage of the new possibilities presented by technologies to provide flexibility to the energy system, not only from the supply side but also from the **demand** side.

Flexibility	Increasing the flexibility of the system while taking advantage of the possibilities both from the side of the energy supply and from the demand of the energy-consuming sectors

2.4 DIMENSION INTERNAL ENERGY MARKET

The objectives corresponding to the dimension of the Internal Energy Market of the Plan respond to the need to have a more competitive, transparent, flexible and non-discriminatory energy market with a high degree of interconnection that promotes cross-border trade and contributes to energy security.

At the same time, this market must be focused on consumers and their protection while establishing the necessary conditions to ensure a just transition and addressing the situations of energy poverty. These objectives are addressed from the following aspects (the electric and gas markets are specifically dealt with in each one):

1. interconnectivity;
2. energy transmission infrastructure;
3. integration of the internal energy market;
4. implementation of the National Strategy against Energy Poverty.

In relation to the interconnectivity of the electricity market, the interconnections not only improve efficiency of the systems by contributing to a more efficient allocation of generation installations, thus reducing the need for duplicate installations on both sides of the borders, but they are essential for security of supply - particularly in a scenario of high penetration of electricity generation from non-manageable renewable sources.

They are also the essential element for achieving an internal electricity market with competitive and homogeneous prices, since they allow supply to be increased (through imports) to those markets where, at a certain time, and depending on existing weather, technical and economic conditions, the price is relatively high, thus moderating prices in those markets and bringing them closer to those in export markets at that time.

The economic benefits derived from an adequate degree of electricity interconnection include the following:

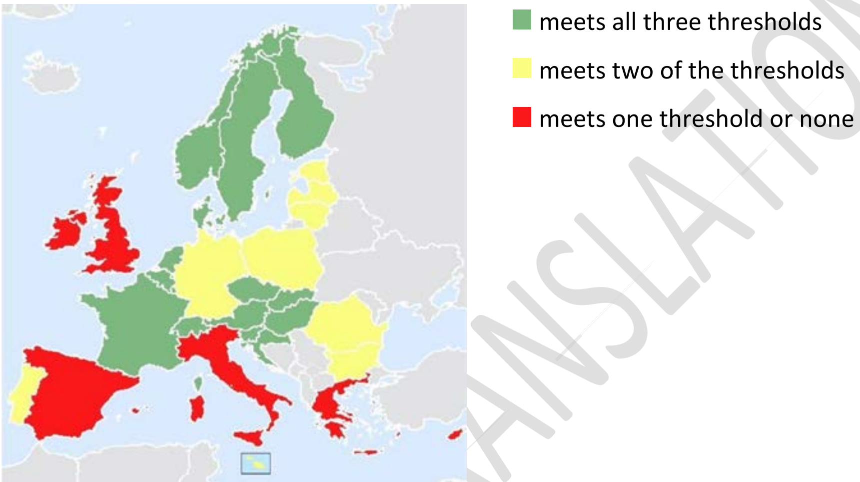
- savings in reinforcement investments in the transport and distribution network;
- lower costs derived from the guarantee of immediate services through balancing energies that are mobilised effectively;
- minor discharges of renewable energy (losses of income for producers due to energy being generated that is not consumed, nor can it be exported);
- lower cost of risk coverage compared to the higher volatility of the market price.

In this regard, the level of interconnection of the Iberian electricity system with the rest of the European continent falls below the objectives established by EU legislation. Currently, the interconnection ratio of Spain is less than 5 % of the generation capacity installed in our system. Moreover, if one considers that the real support to the Iberian Peninsula can only come from the Central European system through the French border, the interconnection ratio is 2.8 % (after the last interconnection between Spain and France through the eastern Pyrenees, which was put into service in 2015). This means that the Peninsula continues to be very much an ‘electric island’.

Additional and more specific thresholds that serve as indicators of the urgency of the necessary action, established by the Commission Communication on strengthening Europe's energy networks (COM (2017)718) (see figure 2.10), and recalled in Regulation 2018/1999 on the Governance of the Energy Union and Climate Action, are also not met. These thresholds are:

1. annual price differential exceeding EUR 2/MWh;
2. nominal transmission capacity of interconnectors below 30 % of peak load;
3. nominal transmission capacity of interconnectors below 30 % of installed renewable generation

Figure 2.10. Situation regarding the three thresholds included in document COM (2017)718[30]



Source: Ministry for Ecological Transition, 2019.

In short, in 2020 and with the planned interconnections, Spain will be the only country in continental Europe falling below 10 % (an objective set by the European Council of Barcelona in 2002). Subsequently that objective was raised to 15 % for 2030.

Electricity interconnection	Achieving an interconnection level of 15 % in 2030

Apart from the measures proposed in Chapter 3, it is important to remember the role of indicative planning, which is a basic tool for safeguarding security of supply, increasing the penetration of renewables and reducing technical restrictions on networks. Its main objectives include increasing the level of interconnections.

In the case of the gas system, optimising the use of the existing interconnection capacity in order to facilitate access to other gas sources and move towards price convergence before undertaking new infrastructures is considered a priority. This objective will contribute to a reduced gas bill for consumers.

[30] The thresholds are: (1) 'additional interconnections should be prioritised if the price differential exceeds an indicative threshold of 2€/MWh between Member States, regions or bidding zones'; (2) 'countries where the nominal transmission capacity of interconnectors is below 30% of their peak load should urgently investigate options of further interconnectors'; (3) 'countries where the nominal transmission capacity of interconnectors is below 30% of installed renewable generation capacity should urgently investigate options of further interconnectors'.

In the electricity system, the integration of a significant volume of renewable generation capacity, both on the mainland and in non-peninsular territories, makes the reinforcement and growth of the transmission and distribution lines in Spanish territory necessary. This includes existing connections between the mainland and non-peninsular systems and interconnections between island systems. Likewise, it is necessary to develop management and storage mechanisms for non-manageable renewable energies in order to allow the reduction of the discharge of renewable generation.

In the specific case of island territories, the increase in interconnections within their electricity systems will have a direct impact, since in the production mix of these systems there is a greater contribution of coal, fuel or diesel power plants than in the mainland mix.

Finally, we should highlight the role the specific control centre of the electricity system operator (Red Eléctrica de España), which optimises the proper integration of renewable energies, cogeneration and waste, allowing us to keep track of them in the face of possible variability of the predictions and their integration into the balancing services.

Electric transmission infrastructure	Integration of renewables and reinforcement in non-peninsular territories
Integration of the electricity market	Making the market work optimally

This objective has to become reality through the storage of electrical energy, the optimisation of the use of the hydroelectric resource, and giving information to consumers. With reference to the gas market, the focus is also on strengthening and developing the market while at the same time protecting the consumer.

Integration of the gas market	Strengthening the market, ensuring the protection of gas consumers

This general objective, in turn, translates into specific objectives of gas logistics, consumer information and streamlining of administrative procedures.

Protecting vulnerable consumers	Implementation of the National Strategy against Energy Poverty

The National Strategy against Energy Poverty is set up as an instrument that enables the phenomenon of energy poverty to be addressed from an integrated perspective and with a medium and long-term vision. By means of the Strategy, a diagnosis and characterisation of the problem will be carried out, official measurement indicators will be designed, energy poverty reduction objectives will be established for the medium and long-term, and specific measures will be proposed in order to achieve these objectives, as well as their financing methods. In this Strategy, particular attention will be given to income thresholds and the vulnerable situations of the target groups.

2.5 DIMENSION RESEARCH, INNOVATION AND COMPETITIVENESS

2.5.1 National objectives in RIC and national financing objectives

National objectives	
	• Aligning Spanish policies with the objectives pursued internationally and by the European Union in terms of RIC in energy and climate. • Coordinating the RIC policies in energy and climate of the Public Administrations with the other sectoral policies. RIC in energy and climate is a cross-cutting challenge that affects research activities applied to other areas. • Promoting public-private partnership and business research and innovation.

Research and innovation policies offer significant mitigation and adaptation potential and governments have a key role to play in developing and introducing new technologies and practices with low emissions into the markets.

The generation of renewable energy and the fight against climate change are two priority objectives for Spain in order to ensure a competitive and clean supply that enables adequate sustainable economic growth and social welfare. Research, technological development and innovation constitute one of the essential pillars for the achievement of these objectives. For this reason, historically, the State Strategies and Plans make specific reference to research areas related to sustainable development and the fight against climate change and decarbonisation.

Specifically, in the latest **State plan for scientific and technical research and innovation 2017-2020,** research areas are considered such as: the development of the next generation of renewable energy technologies; the design of flexible and distributed networks and management systems; the design and development of efficient energy systems; methods of reduction, capture, storage and use of carbon; the treatment of waste for energy purposes; research in the field of nuclear energy; hydrogen technologies; the development of clean combustion technologies; progress in the areas of sustainable mobility and the modal shift in transport; the promotion of sustainable building; low-carbon technologies and actions to mitigate and adapt to climate change, such as climate observation; the integrated and sustainable management of systems and natural resources; the impact of and vulnerability to climate change and natural disasters; the sustainable and resilient management of water resources, among others.

For the period 2021-2030, this dimension represents an effort to align Spanish policies with the objectives pursued internationally and by the European Union in terms of RIC in energy and climate.

Consequently, the RIC dimension will contribute to the objectives established in the Paris Agreement, the 2030 Agenda for Sustainable Development, the 2030 Framework for climate and energy, the strategy ‘Europe 2020’, the ‘Innovation Union’, the ‘European Research Area’ and the future framework programme ‘Horizon Europe’ while always taking into account the specificities of the Spanish Science, Technology and Innovation System, its scientific, technological and innovation capacities and the general characteristics and interests of the country and its territories.

In particular, the RIC activities to be developed within the framework of this Plan are, in turn, aligned with the 'Energy Union' and the **Strategic Energy Technology Plan (SET Plan)**, and it is important to highlight that the projects and actions in the field of research and innovation take into account the priorities included there - especially those that are relevant for Spain - in which the Spanish System of Science, Technology and Innovation has proven scientific and technical strengths. In this sense, it is essential to coordinate the RIC policies on energy and climate of the Public Administrations and coordinate these with the rest of the sectoral policies, in order to generate the synergies and complementarities required. This, in turn, implies the co-responsibility of the competent administrations and the adoption of shared criteria in terms of management, evaluation and, where appropriate, the implementation of co-financing models.

The participation of players of all the levels (of Central Administration, regional and local) is important in order to achieve the energy transition. In this regard, the Autonomous Communities are in a privileged position to exploit their strengths and increase their competitiveness and innovation potential in order to contribute at a national and EU level. In this regard, within the framework of the Association Agreement of Spain 2014-2020 with the European Union, the **Spanish Strategy for Science, Technology and Innovation** and the **State plans for scientific and technical research and innovation** jointly define the national framework of **smart specialisation** (RIS3) that the Autonomous Communities refer to through their corresponding research and innovation strategies for intelligent specialisation.

The INECP supports alignment with the instruments and strategic objectives defined in the framework of the 'smart specialisation strategies' -RIS3-, which represent the *ex ante* condition required by the European Commission for the allocation of funds corresponding to the cohesion policies and therefore generating a competitive and sustainable model of economic, social and territorial development based on innovation.

In this framework, we will rely on the **Energy Platform S3P-Energy,** created by the European Commission, within the framework of the **Smart Specialisation Strategy** in order to align the objectives of RIC in energy and climate (at the European, national, and regional level), connect with the regions and therefore avoid possible fragmentation. The energy platform includes partnerships on bioenergy, marine renewable energy, smart grids, solar energy and sustainable buildings. The smart specialisation strategy can also contribute to the development of regional and local energy and climate plans.

The RIC in energy and climate must necessarily combine the results of fundamental research, development and technological and non-technological innovations. This must be introduced both for the processes of dissemination and adoption of the proposed solutions, and for the generation of new products and services that help solve these challenges.

In addition, it will be **necessary to promote public-private partnerships and business research and innovation**, which will respond to flexible structures of national and international collaboration. Many such structures require mobilising private investment while putting into practice new schemes for public and pre-commercial purchases of scalable solutions based on the developments achieved.

Finally, it should be mentioned that due to its characteristics, **this is a cross-cutting challenge that affects research activities applied to other areas** such as public health and the impact of climate change, the transformation of natural land, air and marine ecosystems, the conservation of cultural heritage, the development of digital applications and the deployment of smart grids. Research in social sciences and humanities focused on processes of environmental, economic, technological and social adaptation relevant to Spain and Europe deserves to be given special attention.

In view of all of the above, **the Government of Spain will consider a Strategic Action on Energy and Climate Change** in the forthcoming Spanish Strategy for Science, Technology and Innovation 2021-2028 and in the forthcoming State Plan on Scientific and Technical Research and Innovation 2021-2024, so that the necessary instruments and methods for participation can be accommodated in order to comply with the international and European commitments undertaken (Paris Agreement, Sustainable Development Goals, 2030 Climate and Energy Framework).

We should clarify here that the strategic actions correspond to horizontal sectors or technologies. Through these actions, the Government covers its most **resolute and significant commitments in terms of RIC**, with an integrated concept in which the research carried out is valued, as well as its transformation into processes, products and services for society.

Therefore, the Strategic Action on Energy and Climate Change has the objective of promoting RIC for the energy transition and of accelerating the full decarbonisation of the economy and the implementation of a model of sustainable development and resilience to climate change that provides the economic and regulatory signals that give stability and security to investors and other economic players. In particular, a sustainable energy model that encourages the use of renewable energy sources, energy efficiency, the development of clean combustion technologies or emerging technologies, progress in the areas of sustainable mobility and the modal shift in transport, promotion of sustainable building and non-energy climate change mitigation, climate observation and adaptation to climate change.

2.5.2 Specific objectives for clean and low-carbon energy technologies

Specific objectives in energy

At a European level, the ‘Energy Union’ aims to achieve an integrated energy market on a continental scale, with a growing energy interconnection, which promotes competition and the efficient use of resources, including measures to stimulate the use of renewable energy sources that contribute to decarbonising the energy system within the framework of international agreements on climate change. In order to achieve these objectives in the 2030 horizon, it will be necessary to have technologically feasible solutions and innovations not only in terms of energy efficiency and clean energies but also on consumption patterns, ecodesign, governance, finance and transport, among others.

The priority RIC energy objectives for Spain concern the following aspects:

- the development of geological capture and storage technologies, transport and use of CO_2 and clean energy sources (wind, solar photovoltaic and solar thermoelectric, bioenergy, marine energies, biomass, geothermal and hydrogen) and energy efficiency;

- the competitiveness to improve the effectiveness of the Spanish and European network through the development of the internal energy market;
- security of supply, in order to coordinate the national energy supply and demand better in an international context; and
- the social and technological drive towards patterns of lower energy consumption.

Taking into account the international commitments acquired, coordination of national actions with the different European initiatives is required, particularly with the Strategic Energy Technology Plan (SET Plan). Special support will be given to the following technologies:

- Innovation in renewable energy technologies in which Spain already has a competitive or leadership position with high levels of participation by Spanish companies in the market (in line with the European objective of global leadership in renewable energies [31]).
- Research, innovation and competitiveness in those technologies that have the greatest potential for socio-economic benefit in Spain (industrial development, rural settlement, etc.).
- Innovation in technologies that have reached high levels of technological maturity.[32]
- Renewable energy technologies that contribute to the flexibility and optimisation of the energy system as a whole[33] (especially in the case of the electricity system), taking into account the objectives sought: generation based on renewable primary resources (usually variable), support for the inertia of the system, and market potential via international interconnections (including the major international lines). Special attention will be paid to manageable renewable energies such as solar thermoelectric energy with thermal storage, biomass and other storage options.
- R&I in other technologies that contribute to manageability and are necessary in the transition process. The introduction of renewable gas (biomethane and synthesis gas) in the gas structure of the country. Additionally, the national gas structure, with a parallel deployment to its electrical structure, allow us to think about the application of power to gas (conversion from electricity to gas) as a large-scale storage subsystem.
- Also, with the aim of increasing flexibility of the system, as well as increasing the competitiveness of renewable generation systems, it is necessary to innovate with electrical storage systems and optimise their management.
- Digitalisation of the electrical system. One of the pillars of energy transition is the massive deployment of decentralised generators (with and without storage) that

[31] On 30 November 2016, the European Commission presented a package of measures in order to preserve the competitiveness of the European Union, since the transition to clean energy is changing global energy markets. The objectives are: putting energy efficiency first, achieving global leadership in renewable energies and providing a fair deal for customers.

[32] Enabling measures will be necessary in order to allow energy technologies (ET) in their final phase of development (high levels of technological readiness) to find their way to the market. Consequently, mechanisms must be established to support it (for example, through innovation windows, promotion of Priority Technology Initiatives, *innovation paths* or other equivalent systems).

[33] The implementation of low-carbon technologies that provide flexibility to the system is essential in order to achieve high penetration rates of intermittent (or flowing) renewables. Without this flexibility, despite offering low generation costs, renewables such as PV, wind and others, would have a lower penetration ceiling.

interact with the electricity system and the market. Another pillar is the coupling of demand to generation as a result of the demand management programmes favoured by digitisation.

- Likewise, while Spain keeps its nuclear power plants in operation it is necessary to permanently reinforce their safety, optimal operation and waste management. However, given the scenario of orderly and staggered closure of the nuclear fleet provided for in the INECP throughout the decade between 2025 and 2035, specific research and development efforts are required in this area which will be carried out in collaboration with other EU nuclear countries with experience of total or partial closure of their nuclear parks.
- Sustainable transport: to promote a change of model in the transport system based on sustainable mobility, the application of new solutions that are less polluting, safer, better integrated and capable of responding to the demands and uses of society.
- Renewable fuels for the transport sector:
    - the development of advanced biofuels obtained in a sustainable manner from renewable raw materials;
    - hydrogen or derivatives thereof.
- Low-carbon technologies: as a matter of priority, the applications in the transformation industries with high energy consumption, in order to improve efficiency in the consumption of energy and resources.
- RIC in Energy Efficiency. Mainstreaming of energy efficiency affects various fields such as industry, transport or building and, in each of these areas of action, all the technologies affected are susceptible to development to improve their energy efficiency (often in combination with the development of digitisation and smart grids and with the implementation of renewable energies). For example, improvements are needed in buildings in order to facilitate the deployment of:
    - heat and cold generation systems;
    - the use of renewable energy in urban heating and cooling networks;
    - the use of renewable energy in buildings;
    - renewable energy produced by cities, energy communities and self-consumers;
    - active and passive solutions in the energy upgrading of buildings.

Specific objectives on climate change

RIC activities aimed at climate change must comply with the commitments arising from the Paris Agreement and the EU 2030 Climate and Energy Framework and respond to the issues raised in this National Plan for Adaptation to Climate Change (Plan Nacional de Adaptación al Cambio Climático, PNACC), the European Strategy on Adaptation to Climate Change, the 2020 road map for non-ETS sectors, the forthcoming Law on Climate Change and Energy Transition (Ley de Cambio Climático y Transición Energética) and the forthcoming Strategy for decarbonisation of the economy by 2050.

Climate change is one of the main threats to our society, with implications in all dimensions of sustainable development. It is a key aspect of European and international policy and requires action to be strengthened in research, development and innovation in scientific knowledge, and in the fight against its causes and effects in Spain due to the high vulnerability of the country in this regard.

For this reason, it is essential to improve the scientific knowledge of the processes and the operating mechanisms of the oceans, land ecosystems and the atmosphere, as well as adaptation and mitigation options. Thus, aspects related to water resources, particularly integrated water management systems, and technologies aimed at the efficiency of their use in irrigation, rural, urban and industrial environments and all activities that make it possible to make progress in the protection of aquatic ecosystems, seas and oceans deserve special attention.

Because of their particular significance and impact on the whole territory, activities aimed at preventing and mitigating the devastating effects of forest fires on biodiversity, resources, and the natural, rural and urban environment must be encouraged. Desertification, forest fires, soil erosion and impoverishment, the reduction of freshwater resources and the progressive salination of water reserves, together with pollution, overexploitation and loss of biodiversity, are clear signs that we urgently need to make efficient use of natural resources and that environmental integrity needs to be ensured as a factor in competitiveness and socio-economic development for the country.

It is necessary to mobilise the transition towards a new productive model that reduces pressure on the environment, natural resources and raw materials and triggers the application of less polluting industrial processes, and to enhance existing technological development linked to the need of have advanced instruments in order to face the challenges linked to climate change.

Funding objectives

Currently, a substantial number of regional, national and European policy programmes and instruments exist in order to encourage innovation, growth and jobs or to promote interregional cooperation on energy and especially on climate. The environment and efficiency in the use of resources and energy are already very important categories in the **Investment Plan for Europe** [34] —the Juncker Plan—, in the current EU research and innovation programme, **Horizon 2020** , in the **European Research Council**, in the **Marie Skłodowska-Curie** actions, and in the **European Structural and Investment Funds**.

For example, in the first four years of Horizon 2020, Spanish entities obtained subsidies amounting to EUR 2.816 billion. Spain therefore reaches a return of 10 % EU-28 and is in the fourth position in the country ranking according to the subsidy received. By thematic areas, Spain stands out as second with the greatest return in the societal challenge ‘Climate action, environment, resource efficiency and raw materials’ with 13.2 % EU-28[35]. With regards to challenge 3 ‘Secure, clean and efficient energy’, Spain is in third position in the country ranking with a return of 11 %.

[34] COM(2014) 903 on an Investment Plan for Europe

[35] Source: CDTI, resultados provisionales mayo 2018 (CDTI, provisional results May 2018) http://www.cdti.es/index.asp?MP=9&MS=31&MN=2&TR=A&IDR=7&xtor=RSS-4&id=1354

In line with the Paris Agreement and the commitment to the United Nations Sustainable Development Goals, the Commission's proposal on the **multiannual financial framework for the period 2021-2027** establishes a more ambitious goal for the integration of the climate dimension into all EU programmes, with the overall goal of **25 % of Union spending contributing to climate objectives.**

Likewise, the proposal of the European Commission for the **new research and innovation programme of the EU, Horizon Europe, proposes that 35 % of its budget be allocated to climate objectives.**

The Commission has also proposed to mobilise approximately **EUR 11 billion for** market instruments, including financial instruments and budget guarantees, in a specific section of the **Invest EU Fund, which will allow the mobilisation of EUR 200 billion in private investment** in order to support research and innovation.

On the basis of the success of the European Fund for Strategic Investments [36]in its first year of operation, the Commission has proposed extending its duration until the end of 2020. The **European Fund for Strategic Investments EFSI 2.0** focuses even more on sustainable investments in all sectors in order to contribute to the achievement of the objectives of the Paris Agreement and help make the transition to an economy that is efficient in the use of resources, circular and low-carbon. At least 40 % of the EFSI projects under the infrastructure and innovation chapter should contribute to the fulfilment of the EU climate action commitments in line with the objectives of the Paris Agreement.

For its part, the **Innovation Fund**, within the framework of the EU emission trading scheme, will support the demonstration on a commercial scale of pilot projects and the most advanced technologies (dedicated to renewable energies, storage, energy efficiency in intensive industry and Capture, Storage and Use of CO_2).

Lastly, within the scope of the Clean Energy Sub-programme of the LIFE Environment and Climate Action Programme, the European Commission has proposed an allocation of EUR 1 billion.

The objective of Spain in terms of RDI is to invest no less than 2.5 % of GDP annually and consistently over the next forty years, regardless of economic cycles. A significant part of this investment will be dedicated to RIC to combat climate change and decarbonise the economy. This percentage is currently being evaluated. In any case, it will be aligned with the objectives and ambitions of the EU on this matter.

2.5.3 Objectives of competitiveness

The achievement of the objectives of the Integrated National Energy and Climate Plan 2021-2030 in terms of energy efficiency and generation of energy from renewable sources has a positive impact on the competitiveness of the Spanish economy (see Chapter 4), because:

- energy efficiency and management are strategic tool for improving competitiveness in the industry in particular, and in the business sector in general, as a result of a reduction in the energy bill;

[36] COM(2014) 903, An Investment Plan for Europe.

- the high penetration of renewable energies for the generation of electricity, due to their nil marginal cost in most technologies, guarantees competitive energy costs and less exposure to the risks of price variability in the long term;
- finally, focusing particularly on this dimension of research, innovation and competitiveness, the National Plan presents an opportunity for the development of a high added-value capital equipment and services industry.

Among the measures of the National Plan that address the issue of competitiveness is the ALINNE public-private partnership platform. One of its objectives is to maximise the impact of research activities on competitiveness.

3 POLICIES AND MEASURES

3.1 DIMENSION DECARBONISATION

The Plan proposes 20 measures that seek to decarbonise the economy. Of these, ten aim to specifically promote a renewable technology or a technology relating to one of the three energy uses; three measures take a cross-cutting approach to all renewable sources, technologies and uses; three measures target non-energy non-ETS sectors; and two measures relate to the land-use, land-use change and forestry (LULUCF) sector. Finally, one measure relates to the application of the emissions trading system and another to taxation.

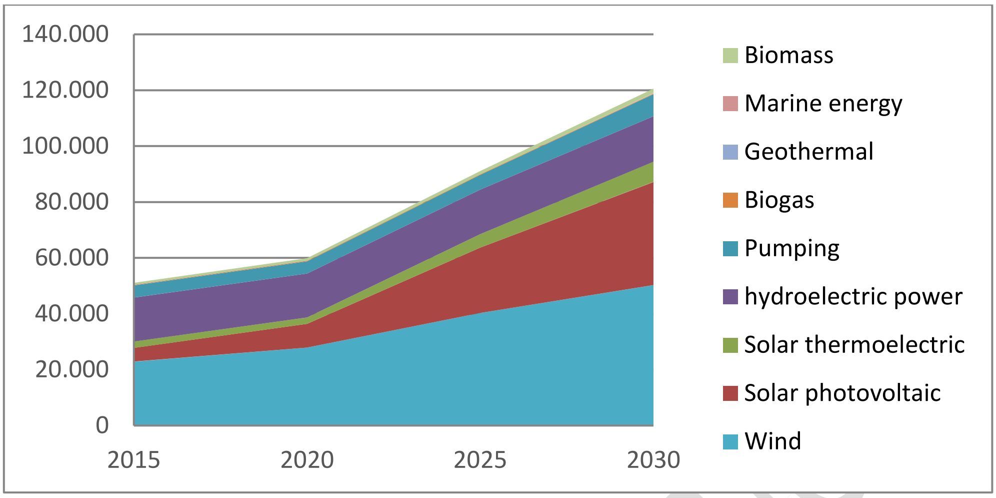
In relation to the previous chapter, it should be noted that the electricity generation and transport sectors are responsible for the greatest reduction in greenhouse gas emissions. In the former, this is a consequence of the very substantial deployment of renewable technologies and the gradual movement away from carbon. In the latter, it is a consequence of a range of actions, among which the modal shift towards low-emissions or emissions-free means of transport stands out, and of the generalised implementation, from 2023, of central zones ('almendras' or 'almonds') in Spanish cities with more than 50 000 inhabitants, access to which will be increasingly restricted for the most polluting vehicles. In the interest of methodological consistency, this measure is explained in detail in Section 3.2 (Energy Efficiency Dimension) and appears as **Measure 2.1. Modal shift measures (promoting more efficient modes of transport).**

3.1.1 Specific measures promoting renewable energies

To achieve the decarbonisation objectives, it is necessary to significantly increase the use of renewable energies for generating electricity and to electrify a significant proportion of energy demand. The measures proposed below are expected to increase the share of renewable energies in the electricity system to 74 % by 2030.

The projections analysed in the Plan account for the entirety of the investment and the operating and maintenance expenditure required to make the planned increase in the use of renewable energies for generating electricity profitable. The design of the market and remuneration mechanisms for the electricity system that will be implemented will determine how these investments and this expenditure will be mobilised, as well as their sources and the mechanisms through which the investments will be recovered.

Figure 3.1. Installed capacity of renewable technologies (GW)



Source: Ministry for Ecological Transition, 2019.

Measure 1.1. Development of new facilities for generating electricity using renewables

a) Description

Over the 2021-2030 period, the installation of **57 GW** of additional capacity for generating electricity using renewables is planned. To this end, it will be necessary to take advantage of the strengths of each renewable technology available with a strategic vision.

In the case of mature technologies, their main strength is their demonstrated capacity to make high energy contributions, minimising the amount of public aid required. Therefore, it makes sense for the development of new facilities to continue to be supported through competitive tendering mechanisms, such as the tender procedures launched in Spain in 2015, adapted as necessary to improve their efficiency and effectiveness.

Furthermore, as regards technologies that have not reached technological maturity (for example, marine energy or offshore wind energy), it is necessary to adapt the public funding mechanisms to the specificities of each technology and of the different territories (in particular those not on the mainland), so as to take account of the fact that they are still unable to compete in terms of generation costs, but that they offer an added value to the system by diversifying the technologies, energy sources and locations involved therein, as well as their potential for future development.

Finally, participatory citizens' projects have additional advantages, such as having the greatest socio-economic impact or increasing social acceptance and public awareness of the benefits of renewable energies. Consequently, it is necessary to develop specific measures to promote them.

b) Objectives addressed

Development of renewable energies, citizen participation and innovation.

c) Mechanisms

The following mechanisms are planned for the development of new renewable energy facilities:

- **Calls for tenders for the allocation of a specific remuneration scheme**

  The Government will define a **multi-annual schedule of tenders for the period covered by the Plan** designed to offer predictable and stable income with a view to facilitating investment decisions and their financing. Unless a change in market conditions makes it necessary to act otherwise, **the product in the calls for tenders will be the electricity to be generated** and the variable on the basis of which an offer will be made will be **the price of this energy**.

  It will be possible to **distinguish between different energy generation technologies** depending on their technical characteristics, manageability or capacity to guarantee firm power, location criteria, technological maturity or anything else that could guarantee the transition to a decarbonised economy.

- **Local participation in renewable generation projects**

  Mechanisms will be established via regulations **to promote a diversity of actors and the existence of participatory citizens' projects**, to promote both social and territorial cohesion and a just transition, and to take advantage of the opportunities presented by the new decarbonised generation model. Specifically, it will be possible to establish a minimum proportion of the investment in renewable energy projects that should be open to participation by people or bodies from the municipality or local area where the projects are located, so they have the opportunity to be co-owners or co-investors.

  The possibility will be assessed of establishing a support mechanism through which participatory citizens' projects can enter into a contract of sale for their electricity at a fixed price tied to the result of the tenders. An annual quota will be reserved for participatory citizens' projects and will be granted to the first that request it and comply with the requirements until the energy quota is met. Furthermore, the question will be assessed of whether the projects that join the support mechanism could have public guarantees to facilitate financing and make it cheaper.

- **Specific programme for developing technologies**

  Some energy generation technologies (for example, marine energy and energy from offshore wind in deep waters), although they remain uncompetitive, have great potential. For these, a specific tender schedule is proposed with a reduced power capacity that will make it possible to accommodate demonstration or flagship projects. Depending on the specific needs in each case the tender could be supported with public financing.

- **Specific programme for territories not on the mainland**

  Aid programmes are planned for new renewable energy facilities, in particular those that can provide a guarantee of power.

  This programme is justified by the fact that the electricity systems in territories not on the mainland are subject to special regulations that mean that conventional backup technologies are being use to a greater extent and that generation costs are higher. Furthermore, investment and operating costs are higher than those of sites on the mainland, such that it would not possible to compete on a level playing field with them as regards renewables tenders.

d) Responsible bodies

The calls for tenders must be made by the Ministry for Ecological Transition (MITECO). The MITECO and the Governments of the Canary and Balearic Islands and the cities with a Statute of Autonomy must collaborate on drawing up specific programmes for territories not on the mainland.

Measure 1.2. Integration of renewables into the electricity grid

a) Description

Based on the data submitted by REE (‘Renewable energy in the Spanish electricity system. 2017’ published in June 2018), in Spain renewables represented 46 % of the installed capacity of the entire generator stock at the end of 2017. In comparison with other European countries, in 2017 Spain was in sixth position in terms of renewable generation capacity, with a renewables quota as a proportion of total generation above the European average. This level of penetration is even more commendable, given that the renewable technology with the highest participation in the electricity system is wind energy without storage (which contributed 18.2 % of the electricity generated in 2017) and that this technology is difficult to manage.

This level of integration of renewables has been possible thanks to **REE’s Special Regime Control Centre (CECRE).** CECRE has been a world-leading centre for more than a decade, managing and monitoring, in real time, the energy generated by wind farms, which are assigned to generation control centres that channel the system operator’s instructions.

This National Plan seeks to cover 74 % of electricity consumption with renewables by 2030. In order to minimise renewable energy wastage, to link electricity generation and demand and to reduce the need for fossil fuel power stations as a backup to guarantee the stability of the system, it is necessary to develop the right legislative framework and drive forward specific actions that will make it possible to move towards a more flexible electricity system through the use of storage and demand management.

In fact, increasing the flexibility of the system would make it possible to achieve the renewable energy generation objectives set out in this INECP without ever increasing the use of natural gas combined cycles as a backup technology.

b) Objectives addressed

Increasing the energy generated from renewables, securing the supply and promoting the participation of new actors.

c) Mechanisms

It is necessary for the system to properly accommodate the large renewable energy generation capacity promoted by the Plan in a way that ensures the security of the system. The following actions are planned for this purpose:

- **Adaptation of electricity transmission and distribution network planning**

  The development and strengthening of the electricity transmission and distribution infrastructure must be adapted to the forecast development of renewable generation through the creation of new nodes for transferring power and the strengthening of existing ones, as well as the development of new interconnections, internationally and with systems not based on the mainland. It is essential that the public and the administrations in the territories where these network infrastructure activities are planned participate in the planning of these activities in order for the plans to be implemented properly.

- **Definition of the network connection capacity**

  In order to enable the new renewable energy generated to be transferred without oversizing the network it is necessary to review the criteria used to define the connection capacity of each node on the network, so that it is defined according to the maximum permissible power transfer and the associated safety conditions and not according to the peak capacity of the installation to be connected. Furthermore, it is necessary to guarantee the transparency of the connection capacity available on the network, with the aim of facilitating the development of new renewable capacity in the right locations.

- **Development of storage systems**

  As regards storage, the growth of hydraulic **pumping** technologies should be highlighted, with an **additional capacity of 3.5 GW.** This capacity, which offers greater power dispatch capability, will be complemented by the staggered introduction of batteries into the system, the aim of which must be to reduce wastage and maximise the production capacity of non-dispatchable renewable technologies. These **batteries** will have a capacity equivalent to approximately **2.5 GW** in 2030, with a maximum of two hours storage at full charge.

  In particular, it will be possible to issue calls for tenders in which the tendered product would be the incorporation into the electricity system of firm backup power or capacity from technologies that do not use fossil fuels, even if they do not involve an increase in terms of electricity generated per se, for example, batteries. In this case, the variable on the basis of which an offer would be made would be the annual additional remuneration per unit of firm power (MW) or storage capacity (MWh).

  Furthermore, in line with technological developments and the development of different storage technologies, the possibility will be assessed of changing how **pumped storage capacity operates so that its main objective would be to stabilise the system and help integrate renewables into it.**

- **Demand management**

  Demand management enables both greater variability in electricity generation to be accommodated and alternative mechanisms to be provided for the stability of a system with an ever-lower degree of inertia as a result of the departure of thermal power station. The industrial sector plays a significant role in this respect, given that it is a major energy consumer.

  At the same time, **the new figure of the demand aggregator** will enable participation of the tertiary and residential sectors in providing services to the system, participation in providing services to the system via remuneration aggregators, and therefore the possibility of new income for electricity consumers.

In a system with a high penetration of renewables like that envisaged, the management of demand will be standard practice for major consumers or those whose demand is able to be aggregated, as may be the case for electric vehicle recharging parks, battery parks, or distributed climate control systems.

- **Operating procedures**

  The operating procedures will be reviewed and updated in line with economic and technological changes.

d) Responsible bodies

General State Administration (MITECO, Ministry of Science, Innovation and Universities), REE, autonomous regional administrations.

Measure 1.3. Development of self-consumption using renewables and distributed generation

a) Description

The self-consumption of renewables brings energy generation closer to its consumption and therefore reduces losses, increases the involvement of consumers in the management of their energy and reduces the territorial impact of renewable production. Transforming consumers into producers is also a way to expand possible future sources of financing for the development of renewables.

The following applications should be highlighted in this regard:

- **Development of local energy communities**

  Shared self-consumption enables several consumers within the same community (community of neighbours, a neighbourhood, an industrial park, etc.) to benefit collectively from the same generation facilities located within the community, which means that they can take advantage of the generation capacity and therefore of the investment.

  To make the most of this option it is necessary to **streamline the economic and administrative costs involved** and, in particular, to promote **training and capacity-building programmes for local energy communities** to enable them to obtain the human resources and experts required to identify, process, execute and manage the projects, and obtain the necessary investments.

- **Combating energy poverty**

  Self-consumption systems can be a tool for mitigating energy poverty. In this sense, **the administration's activities relating to the development of public housing estates, access to housing and the activities of the social services** should take account of the potential of self-consumption to reduce electricity bills and the energy dependency of vulnerable families and groups. Measures promoting self-consumption should also aim to make it affordable for everyone in society and, in particular, for those vulnerable consumers who are excluded from self-consumption under market conditions without specific measures.

  Furthermore, shared self-consumption schemes and more dynamic energy management mechanisms enable the Public Administrations and social organisation **to manage situations of energy poverty not only through economic aid but also through the allocation of energy units** (from, for example, the surplus of public or collective self-consumption facilities) at affordable prices or under favourable terms.

- **Self-consumption as a measure of competitiveness**

  Energy is one of the main costs in the majority of economic activities, for which reason energy price increases or variability can be particularly damaging to the competitiveness of businesses.

The generalised installation of self-consumption facilities linked to economic activities (particularly in high energy consumption environments like industrial parks) will enable energy costs to be reduced and stabilised in the long term.

In this regard, special attention should be paid to the development of self-consumption at irrigation facilities, give that this is a sector with intensive energy consumption and that the cost of energy is a fundamental factor in setting the prices of irrigated agricultural products. In order to achieve the successful uptake of this measure it will be imperative for the administrations and irrigating communities to work together.

b) Objectives addressed

Decentralised generation, generation using renewables, and public participation.

c) Mechanisms

The following mechanisms are planned to promote the development of self-consumption:

- **National Self-Consumption Strategy**

  The self-consumption objectives for the 2020-2030 period should be ambitious but attainable, the product of the application of an effective strategy.

  As part of this strategy it will be necessary to analyse the penetration potential for each type of consumer (residential, services or tertiary, industrial), so that indicative objectives can be set over the period.

  The required technical-economic sustainability of the electricity system must also be considered, enabling both the distribution networks and the structure of the electricity tariff to be adapted to the new generation scenario.

- **Soft financing**

  This enables the return of financing based on the economic savings made as a result of the self-consumption of the energy generated.

- **Management by third parties or the energy services model**

  Under this model, specialised companies invest in self-consumption facilities and maintain them, selling the energy produced to the consumers under favourable terms. This avoids the consumer company, family or administration having to make an investment in or take charge of an activity of which they have no experience.

- **Measures to promote local involvement**

  Given the local nature of self-consumption markets, it is necessary to implement promotion measures at the municipal, regional or, where applicable, island level, in particular by simplifying processes (specifically the simple prior notification in the case of installations on buildings that are not protected for heritage purposes) and properly integrating the measures into urban planning instruments. The General State Administration will coordinate the development and monitoring of best practices with local, island and regional bodies for this purpose.

d) Responsible bodies

Local and autonomous regional administrations, with the general framework defined by the General State Administration, specifically the ministries responsible for Energy and Finance.

Measure 1.4. Support for the industrial sector

a) Description

The introduction of renewable energies into industry is an unavoidable challenge if we want to progress towards the systemic decarbonisation of the economy.

The possibility of introducing electricity self-consumption into the industrial sector, although barely happening currently, is an interesting future prospect. Issues relating to self-consumption are analysed in greater detail in other sections of this document.

As regards thermal uses in industry, it should be taken into account that according to the report 'Energy in Spain 2016' published by the MITECO, **final energy demand in the industrial sector was around 24 % in Spain in 2015. Renewable energy sources** covered barely 7 % of this demand (primarily biomass). There is significant potential for biomass, as well as other renewable energy sources (particularly, biogas and solar thermal energy) to contribute more heavily to the decarbonisation of the industrial sector.

When designing the mechanisms, both increasing the penetration of renewables into subsectors that already consume them and diversifying the industrial subsectors will be assessed, given that there is currently a concentration of renewable energy consumption in four very specific subsectors (cement production, pulp and paper production, drinks and tobacco, and timber and timber products), with practically no consumption of renewable energies in the rest.

b) Objectives addressed

Decentralised generation of renewable energies and self-consumption.

c) Mechanisms

The following actions are planned for the development of renewable energies in industry:

- **Aid programmes to incorporate renewable energies into industrial processes.**

  Aid lines for industries or the heating networks that supply them, depending on the potential, cost and characteristics of the technology and the potential improvement in their carbon footprint.

- **Institutional capacity building.**

  The specific incorporation of the energy dimension into industrial policy tools will be promoted (at all levels of the administration).

- **Sectoral agreements**

  Voluntary agreements will be made with specific industrial subsectors to encourage increased consumption of renewable energy.

- **Aid for conducting energy studies, reports and audits that will help the industry to move towards less carbon intensive processes.**

  These studies should identify the different technology options in line with the specific process heat requirements of each industrial subsector (on the basis of the documents on the best available techniques developed within the framework of Directive 2010/75 on industrial emissions), their physical, technical and economic potential, and the identification of challenges and proposals for measures.

d) Responsible bodies

MITECO, the Institute for Energy Diversification and Saving (Instituto para la Diversificación y ahorro de la Energía - IDAE), the Ministry of Industry, Trade and Tourism, autonomous regional governments, sectoral associations.

Measure 1.5. Framework for the development of renewable thermal energies

a) Description

Energy consumption for thermal uses in Spain in 2015 accounted for more than 33 % of the total final energy consumption. In the same year, the contribution of renewable energies to consumption for heating and cooling was around 16.8 %. To achieve the objectives of this plan it will be necessary to double this contribution by 2030.

The revised Renewable Energy Directive provides that Member States must implement the necessary measures to increase renewable energy quotas for consumption for heating and cooling by 1.3 % annually from the value achieved in 2020 (1.1 % if residual heat is not included). The path of thermal renewables envisaged in this Plan would make it possible to exceed this indicative objective.

Renewable energy communities can therefore play an important role in achieving this objective, primarily in relation to the development of heating and cooling networks.

b) Objectives addressed

Penetration of renewable energy sources and displacement of fossil fuels, expansion of technologies for which implementation is limited, participation of new actors and innovation.

c) Mechanisms

- **Measures guaranteeing a minimum quota for renewable energies in the thermal uses sector**

  The subjects affected, the eligible projects and how to account for the energy contribution of each of them will be determined. The economic compensation to be contributed by each subject in the event of non-compliance will also be calculated. It will serve as a source of funds, to be implemented through the aid programmes.

  A certificate/guarantee of origin mechanism will be set up to either certify compliance with these measures or voluntarily verify the renewable origin of the thermal energy for actors not subject to them.

- **Specific measures related to the building sector, in which the Ministry of Public Works will play a central role:**

  - **Integration of thermal renewable energies in building**

    It will be necessary to review and increase the energy efficiency and renewable energy requirements in the Technical Building Code (Código Técnico de la Edificación – CTE), as well as the minimum requirements to be met by thermal installations, by means of the Regulations on Thermal Installations in Buildings (Reglamento de las Instalaciones Térmicas en los Edificios, RITE), for all new buildings and refurbishments.

  - **Aid programmes (loans and subsidies)**

    Aid schemes for installations in buildings or heating networks, depending on the characteristics, potential and cost of each technology and the potential impact on improving the carbon footprint. In particular, specific schemes will be created for:

    ✓ Upgrading existing solar thermal facilities
    ✓ High-efficiency ambient energy equipment to replace obsolete systems
    ✓ Upgrading biomass equipment with other high-performance equipment
    ✓ Geothermal energy facilities with heat pumps and direct use
    ✓ Hybridisation of renewable technologies to achieve 'nearly zero-energy buildings'
    ✓ Integrated, standardised and compact heating and cooling thermal facilities

  It seems advisable to separate the application procedures for small-scale facilities and to design streamlined schemes through the equipment installer or retailer. The Ministry of Finance will also analyse the desirability and viability of possible changes to the fiscal framework to send signals with a view to incentivising electrification and the use of renewables for thermal requirements, and avoiding indirect subsidies for fossil fuels.

- **Measures related to the promotion of heating and cooling networks**

- **Evaluation of the potential of using renewable energies and residual heat and cold in heating and cooling networks and other uses**
- **Legislative development, including:**
  - ✓ evaluation of the potential of these networks in new urban development projects;
  - ✓ development of renewable energy communities linked to climate control networks, including technical training at the municipal level;
  - ✓ ensuring that a cost-benefit analysis will be conducted for each new urban development;
  - ✓ legislative analysis and implementation of measures for potential users.

d) Responsible bodies

General State Administration (MITECO), local and autonomous regional administrations.

Measure 1.6. Advanced biofuels in transport

a) Description

Transport contributes heavily to greenhouse gas emissions (**27 % of the total in 2016**). Consequently, it is a key sector in the decarbonisation process.

Road and rail transport represent almost **one third of total energy consumption**, representing 28 241 ktoe in 2016 (28 368 ktoe according to the methodology established in the Renewable Energy Directive). This year the contribution of renewable energies in this sector reached **5.3 %** (calculated pursuant to the aforementioned methodology).

The revision of the Renewable Energy Directive establishes an overall objective for renewables in transport of **14 % by 2030**. Furthermore, specific objectives for advanced biofuels have been set for 2022 (0.2 %), 2025 (1 %) and 2030 (3.5 %). This overall objective for renewable energies and, consequently, the decarbonisation of transport will be achieved by reducing consumption (for example, by promoting a modal shift) and with the contribution of different technologies (primarily biofuels and renewable electricity).

The measures relating to both the modal shift, particularly in the sphere of urban and metropolitan mobility, and the electrification of transport, understood in terms of the vehicle fleet and recharging infrastructure, are explained in more detail in the Energy Efficiency section of this Plan.

Biofuels are currently the most widely available and widely used renewable technology in transport. Furthermore, in some sectors, such as heavy vehicles (whose consumption is a significant share of the total for road transport) and aviation, they will continue to be the only way to reduce the use of fossil fuels over the coming years. In order to achieve the advanced biofuel consumption objectives, advanced biofuel production must be boosted, as it is still very low. This is due, in some cases, to the limited availability of some of the raw materials required and, in others, to the lack of technological maturity of some of the manufacturing processes involved in producing this type of biofuel.

b) Objectives addressed

Penetration of renewable energy sources and displacement of fossil fuels, and innovation.

c) Mechanisms for the introduction of biofuels

The following mechanisms are planned in this regard:

- general obligation to sell or consume biofuels;
- adaptation of the certification system to specifically cover advanced biofuels and, in particular, biomethane injected into the network;
- aid programme for advanced biofuel production facilities;
- establishing a specific obligation to sell or consume advanced biofuels for the 2021-2030 period;

- promotion of the consumption of labelled blends of biofuels, through measures that enable this option to be offered at service stations, and reduced rates on fuel excise duty to be applied;
- establishing specific consumption objectives for biofuels in aviation.

d) Responsible bodies

MITECO, Ministry of Science, Innovation and Universities.

Measure 1.7. Promotion of renewable gases

a) Description

To date the promotion of renewable gases has been limited mainly to biogas. The particular characteristics of biogas make it one of the few renewable energy vectors that can be used both to generate electricity and to cover energy demand in the thermal sectors.

Furthermore, in terms of reducing greenhouse gas emissions, it achieves not only the reduction derived from using a 100 % renewable fuel, but also an additional reduction in non-ETS emissions (mainly, CH_4), linked to better management of municipal waste, sewage sludge and farm waste.

The measures implemented to date for remunerating electricity generation at biogas plants have not had the results expected, with biogas use in Spain far below the existing potential and far from that achieved in other European countries.

In recent years, the purification of biogas into biomethane has gained importance as, once certain quality requirements are met, the biomethane can be injected into natural gas networks.[37]

With regard to thermal uses, biomethane is of particular interest as regards decarbonising this type of energy demand, primarily in the industrial sector, which, given its characteristics (for example, high temperature, demand for steam), is difficult to meet with other renewables.

Finally, the reduction in the cost of electricity produced using renewables, and of hydrogen electrolysis and energy recovery technologies, hints at the potential of other renewable gases in the medium and long term.

b) Objectives addressed

Displacement of fossil fuels by renewables in the energy mix.

c) Mechanisms

Through the approval of specific plans, the Government will promote the penetration of renewable gases, including biomethane, hydrogen and other fuels produced using exclusively renewable energy and raw materials.

An analysis of the situation of renewable gases in Spain will be conducted, including:

d) Determining the theoretical, technical and economic production potential.
e) Defining a strategy for determining the most efficient use and the most effective way to approach the use of this resource.
f) Designing aid mechanisms to maximise the use of renewable gas, supported if necessary by a certification system to oversee and monitor obligations, as well as flexible mechanisms promoting maximum efficiency in achieving the objectives. Regulations permitting the injection of these renewable gases into the natural gas network have not been ruled out.

g) Responsible bodies

General State Administration (MITECO), local and autonomous regional administrations.

[37] Biomethane produced via the anaerobic digestion of waste materials is considered to be an ‘advanced’ biofuel, i.e. produced from the raw materials under Annex IX.A to the Renewable Energy Directive (Directive 2009/28, amended by Directive 2015/1513). Annex V to Directive 2009/28, on the promotion of the use of energy from renewable sources, establishes that the typical reduction in greenhouse gas emissions resulting from the use of biogas produced from waste is between 80 % and 86 %, depending on the type of waste concerned.

Measure 1.8. Plan for the technological upgrading of existing electricity generation projects with renewable energies

a) Description

Over the 2021-2030 decade, approximately 22 GW of renewable electricity capacity will have come to the end of its statutory useful life. Without a specific plan for the technological upgrading of these projects, it is foreseeable that there will be a reduction in the installed capacity from renewables, particularly concerning old wind farms and small-scale hydroelectric plants, although the earliest biomass, biogas and photovoltaic facilities would also be affected. With the aim of preventing the loss of their energy contribution, it is essential to develop a specific plan for the technological upgrading of these facilities.

Existing renewable electricity generation facilities represent a significant asset given their location in places with high energy resources, the existing infrastructure and network connection capacity, as well as the low environmental and territorial impact of developing new projects in locations already used for generating energy.

Upgrading the generators at or repowering existing projects will enable better use of the renewable resource by replacing obsolete or old systems with new higher powered or more efficient ones. On the other hand, **hybridisation** through the incorporation of different generation or storage technologies into existing projects will enable better use of the available network connection capacity, as well as the territorial concentration of renewable generation.

b) Objectives addressed

Development of renewable energies.

c) Mechanisms

The following mechanisms are planned:

- **Administrative simplification**

  Existing projects have already been subjected to administrative procedures prior to their authorisation. As such, it is necessary to assess, among other options, the possibility of applying the following simplified procedures to them, while safeguarding the proper territorial integration of the infrastructure: exemption from the public interest procedure and the procedure for declaring the property and rights affected; exemption from the requirement to submit a new archaeological study, if one was submitted for the existing facility; reduction in the processing times for environmental impact assessments; reduction in the timescales for notifying other Public Administrations for administrative authorisation and sending the technical conditions for the approval of the project; and simplification of the requirements for accrediting the capacity of the applicant.

- **Setting up coordination committees with the Autonomous Communities**

  In order to coordinate the administrative simplification described above, the active involvement of the Autonomous Communities is required, given their powers in the areas of urban planning and the environment and their knowledge of the reality in each territory.

- **Calls for tenders for the allocation of a specific remuneration scheme for technological upgrading projects**

  Specific tenders are proposed for the technological upgrading of renewable facilities that have reached the end of their statutory useful life. As such, allocated projects that upgrade their equipment and facilities would receive additional remuneration to that from the electricity market. The mechanism envisaged is a competitive tendering procedure, with a multi-annual schedule of tenders, to determine a cost-effective remuneration scheme for the application of public aid, accompanied by the administrative measures required to take advantage of existing infrastructure.

Both generator upgrade projects (with lower or equal capacity to that of the existing facility) and repowering projects (that involve an increase in capacity) will be accepted.

- **Regulation of the end of hydroelectric power station concessions**

  With a view to ensuring the necessary investments and ensuring that power stations do not cease to operate, once existing concessions end, it will be necessary to define the procedures and timescales applicable to these facilities via regulations.

d) Responsible bodies

General State Administration, local and autonomous regional administrations.

Measure 1.9. Promotion of bilateral renewable electricity contracts

a) Description

Globally, cities, communities, companies and individuals are demonstrating their interest in the proactive consumption of 100 % renewable energy. The GO 100% RE initiative has mapped countries, cities, regions, companies and civil society actors, with a total of more than 62 million people that have made the change or committed to make the change within the next decade to 100 % renewable electricity.

The private sector is supporting the energy transition through its proactive demand for renewable energy. RE100 is an international initiative that was launched during Climate Week NYC 2014. It comprises private companies committed to the consumption of 100 % renewable electricity. To date 68 multinationals have committed to consume 100 % renewable electricity. These companies operate in a wide range of sectors: automotive, clothing, finance, food and drink, IT, pharmaceuticals, property, retail, etc.

One possible mechanism for achieving a 100 % renewable electricity supply is to enter into a bilateral contract with an electricity producer. Currently, in Spain, where bilateral contracts have started to take off, the main buyers within this scheme are power marketing companies.

Although bilateral contracts represent an opportunity to complement other remuneration mechanisms and attract financing, they are not without challenges, such as those related to designing an optimal contract that balances the needs of the producer and the consumer, or the lack of knowledge among potential buyers about the existence of this mechanism, to mention a few.

b) Objectives addressed

Development of renewable energies and participation of new actors.

c) Mechanisms

Bilateral contracts with renewable energy producers will be encouraged in the long term with the aim of making electricity prices more stable. In particular, the feasibility will be assessed of minimum contributions of renewable supply for the Public Administrations and major energy consumers.

d) Responsible bodies

Sectoral associations, MITECO, local and autonomous regional administrations.

Measure 1.10. Specific programmes for the use of biomass

a) Description

The management and use of biomass has added value in addition to its simple energy capacity. In particular, it can **revitalise rural areas**, mitigate the risk of **depopulation** and encourage better **adaptation** to the effects of climate change in some territories. Biomass can also play an instrumental role in terms of achieving a **just transition**. As such, biomass is part of various strategies put forward by the different Public Administrations beyond the scope of this Plan.

Furthermore, waste is a key factor in the circular economy. It is therefore necessary to take steps to facilitate the link between and the achievement of both objectives: a just transition and a circular economy.

b) Objectives addressed

Penetration of renewable energy sources and displacement of fossil fuels, participation of new actors and innovation.

c) Mechanisms

Among the specific mechanisms to be implemented, the following stand out:

- **Promotion of energy from biomass with sustainability criteria.**
  - Legislative development throughout the biomass value chain.
  - Strategy for the energetic use of pruning waste from the agricultural sector.
  - Adaptation of air quality obligations for new and existing biomass facilities.
  - Strengthening certification and the principle of proximity to the source for biomass use.
- **Economic aid measures linked to:**
  - Biomass logistics plants.
  - Penalising the landfilling of waste. The possibility will be assessed of establishing agreed principles for the harmonised implementation (and creation, where applicable) of a tax on landfilling municipal and industrial waste, as already exists in various Autonomous Communities.
  - Use of biomass in state-owned facilities.

d) Responsible bodies

General State Administration, autonomous regional administrations.

3.1.2 Cross-cutting measures to promote renewable energies

This INECP includes a series of cross-cutting measures to drive forward the necessary changes to enable a series of structural barriers to be overcome. These include administrative processes, support for pre-commercial technologies or for island sites and measures to enable the actors involved in the energy transition to participate under the best possible terms.

Measure 1.11. Revision and Simplification of administrative procedures

a) Description

Delays in project implementation make it more expensive to move forward with a project. There is a risk that administrative procedures, in terms of timescales or processes, could prolong or generate uncertainty around whether permits will be granted, without necessarily offering improvements or guarantees as regards environmental or social issues, or adaptation to the local area.

Furthermore, current administrative procedures are not, in general, adapted or designed to handle the deployment of hybrid facilities where different renewable energy generation technologies share the same space, unlocking the opportunities for territorial integration that new technologies or ways of organising installations offer.

In conclusion, **it is necessary to revise the administrative procedures involved with a view to streamlining projects and avoiding unnecessary charges for operators.**

The following points should be addressed:

- How to process new renewable facility projects, including alternative hybrid projects involving different renewable technologies, both for feeding the energy generated into the grid and for partial self-consumption.
- The legislative barriers or gaps that hinder the participation of local energy communities in the system.

b) Objectives addressed

- Deployment of renewable energies, including hybrid projects.
- Deployment of decentralised generation (self-consumption and energy communities).
- Streamlining and clarifying administrative procedures for renewable projects.

c) Mechanisms

- **Setting up roundtables with the Autonomous Communities**

  Identifying best practices and ensuring that administrative procedures at the local, regional and state level are clear, objective, effective and efficient and that they deliver value in terms of guaranteeing environmental protection, public interest and the adaptation of the projects to the local reality. This process should be the joint responsibility of all actors to guarantee the equitable development of renewable energy capacity throughout the country.

- **Updating administrative procedures**

  The aim will be to adapt the administrative procedures to include procedures for hybrid projects involving different renewable technologies. The need to revise the administrative processes for technologies with little to no market development will be analysed (i.e. offshore wind and marine energy).

- **Territorial integration of renewables**

  Achieving the objectives set out in this Plan for the development of renewables should be compatible with compliance with the legislation on natural heritage and biodiversity and, in any event, additional measures will be put forward in this regard, such as the creation of spaces for the conservation and promotion of indigenous biodiversity, with special consideration for vulnerable species.

d) Responsible bodies

This review process should involve the local, autonomous regional and state administrations.

Measure 1.12. Generating knowledge, outreach, awareness and training

a) Description

One of the main challenges facing the Plan is the rapid evolution of technology in the energy sector and in efforts to combat climate change. In order to properly design and implement the Plan's measures and mechanisms, and to facilitate informed decision-making by policy developers, it is essential to establish a mechanism to generate the knowledge required.

The transition to a decarbonised energy system is a technological and social challenge. The public plays a central role in this transition, given that it can: (1) encourage policy adoption and enhance the social and environmental accountability of companies, (2) benefit from the jobs created and (3) consume, finance, invest in and produce renewable energy.

This measure seeks to anchor the need to decarbonise in the public consciousness and that of the public and private sectors, and to disseminate tools, technologies and practices to reduce fossil fuel consumption, increase the contribution of renewable energy, reduce greenhouse gas emissions and take advantage of the potential of carbon sinks.[38]

b) Objectives addressed

Proactive participation of all actors in the energy transition.

c) Mechanisms The Ministry of Public Works will take a leading role in all the areas of work presented below.

- **Knowledge generation**

  Objective and approved qualitative and quantitative data and information are of the utmost importance for decision-making and maintaining the trust both of the sector and of the public in general. The MITECO, through the IDAE or other institutional bodies, will work in the area of energy transition with actors in the sector to identify and close information gaps. Studies and analyses will be conducted both on the evolution and potential of energy technologies and on drafting a Spanish strategy for developing offshore wind.

- **Public awareness campaigns**

  Studies carried out both by the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA) show that one of the barriers to the social acceptance of renewables is the persistence of misinformation about them, due, among other factors, to the lack of a united voice and the lack of good communication practices. The mechanisms considered include:

  - Public awareness campaigns at the Energy and Environment International Trade Fair (Genera) held annually in Madrid.
  - The Ministry for Ecological Transition, through the IDAE, in close collaboration with the Ministry of Public Works and other institutional bodies, will identify messages and work with communication professionals (journalists and companies in the sector) to identify a common language for renewable energies, dismantle the prejudices against them and increase their social acceptance among the public.

- **Sectoral information and training campaigns on energy and climate**

  Despite their enormous potential, renewable energies are still poorly understood in some sectors. It is necessary to improve the information available about them, particularly in order that the industrial and tertiary sectors understand the benefits of using them.

  Information and training campaigns can be coordinated in collaboration with the target sectors, by signing agreements between administrations, energy agencies, renewable sector associations, industrial associations, technology institutes, professional associations or associations of developers in the tertiary sector.

  In the past, information campaigns linked to the promotion of programmes for the development of renewable technologies in buildings and industries have had a significant impact in terms of improved user perception of the advantages of using these technologies. These programmes had their own identifying image linked to quality control of the participating companies, in an attempt to ensure the success of the activities.

- **Access to information on consumption**

  Giving the public and the productive sectors easy and instant access to their energy consumption data, as well as the opportunity to share this information with third parties, is necessary in order to harness the potential of energy management, the drive for self-consumption and the development of new services to facilitate decarbonisation.

- **Strengthening the inclusion of ecological criteria in public procurement**

  Public authorities should seek to procure goods, services and works with a reduced

[38] Analyses carried out as part of the European *Keep on track!* project show that many Member States are not on track to achieve their renewable energy objectives by 2020, while the majority of EU citizens consider the EU objective for 2020 to be ‘about right’ or ‘too low’. It is clear that favourable public opinion is not enough to achieve ambitious objectives. Proactive attitudes are required across the board (individuals, corporations and the public sector) to achieve a just energy transition.

environmental impact throughout their life cycle when compared with goods, services and works with the same primary function that would otherwise be procured. The drive towards the use of 'green' criteria in procurement is underpinned by the changes concerning environmental considerations introduced by Law 9/2017, of 8 November, on Public Sector Contracts. The creation of an Interministerial Commission for the incorporation of ecological criteria into public procurement (Royal Decree 6/2018, of 12 January), together with the Green Public Procurement Plan (Plan de contratación pública ecológica) (2018-2025), will serve as the driving force to this end.

- **Promoting the calculation of carbon footprints and their reduction**

  This will be approached from three different angles: A first step will be to promote Spanish organisations' participation in the voluntary register of carbon footprints, compensation and carbon dioxide removal projects created in 2014 by Royal Decree 163/2014, of 14 March. It will be promoted through training, and the development and dissemination of guides and tools. Other areas of work will involve including carbon footprints in public procurement, calculating the carbon footprints of ministerial departments and promoting carbon footprint calculations and reduction efforts among the Spanish municipalities. Finally, the possibility will be assessed of promoting the calculation and registration of the carbon footprint of specific entities.

- **Training professionals**

  To respond to the job creation potential of decarbonisation it is necessary to train qualified people in the different sectors involved.

  The large-scale deployment of renewable technologies in different spheres, particularly at small-scale facilities, will require professionals who are not always adequately qualified (sometimes due to the need to subcontract) to design, implement, operate and maintain facilities of which they do not have an in-depth understanding. It is therefore necessary to expand and improve the professional training available to these professionals in order for the quality of the facilities to guarantee the adequate penetration of these technologies.

  To respond to the job creation potential of decarbonisation it is necessary to train qualified people in the different sectors involved. Powers in the areas of education and training are devolved to the Autonomous Communities. Furthermore, a significant proportion of training is currently done within the companies themselves. Finally, training is one of the focus areas of the trades union.

  The main objective of the training activities is to supply the market with the qualified professionals it will require. To this end, the activities proposed aim to increase the amount of training, improve the existing training and facilitate access to information.

  The European Single Market requires people to be trained in professional skills to facilitate mobility within the EU. Work will be undertaken with associations in the sector and trades union to identify the profiles required to achieve the objectives of the National Plan. The adoption of best practices will be encouraged to increase training for underqualified individuals in cooperation with the organisations affected.

  Finally, awareness-raising and outreach measures will be coordinated to draw future professionals' attention to the job opportunities offered by the energy transition.

d) Responsible bodies

General State Administration (MITECO, IDAE, Ministry of Science, Innovation and Universities), Autonomous Communities, local bodies, energy agencies, renewable sector associations, industrial and services sector associations, training companies, trades union and professional associations.

Measure 1.13. Unique projects and strategy for sustainable energy on the islands

a) Description

Before their generalised implementation, all technologies, including energy technologies, have to go through a process of demonstrating their effectiveness and readiness, a process known as 'the valley of death'. This stage, related to the integration of research, innovation and competitiveness (RIC) policies with market development, is often characterised by a substantial increase in the investment required, combined with a low level of technical reliability. Many technological developments fall down at this hurdle because they do not have the (public and private) investment required to take the leap from the pilot phase of the project. This fact must spur the Public Administrations and the private sector to join forces through the formation of partnerships. Examples of past efforts include Sotavento in the field of wind energy and Ecocarburantes Españoles in the field of biofuels.

The innovative technologies that must be developed in order to achieve the objectives of the National Plan are covered in more detail under the fifth dimension of this National Plan. As regards this measure, it should be noted that the uniqueness in question does not only refer to innovative projects but to the challenges faced as well. These could relate to geographical (for example, being on an island) or market conditions, as in the case of high-temperature geothermal for the large-scale generation of electricity, for which there is no market in Spain despite it being a mature technology, or in the case of offshore wind, which if developed around island territories would involve both types of uniqueness.

It is vital for the public sector, in collaboration with the private sector, to spearhead pilot or demonstration projects that demonstrate the viability of or need for new models or systems that are still not fully market ready.

b) Objectives addressed

Market development for new renewable energy technologies.

c) Mechanisms

Two main mechanisms are proposed:

- **Development plan for unique projects**

  A programme to drive the IDAE's participation in unique or demonstration projects for which the Institute's contribution or public-private collaboration will be particularly important. The support system best adapted to the development of the project can be used (corporate shareholding, financing, third-party financing (TPF), temporary joint venture, etc.).

- **Sustainable energy on the islands**

  In May 2017 Spain, together with the European Commission and 13 other Member States, signed the Political Declaration on Clean Energy for EU Islands, which recognises the islands' potential to be the architects of their own energy transition and the opportunity to take full advantage of these territories as a testing ground for energy transition technologies or policies that could then be exported to the continent. With this objective in mind, the General State Administration will propose sustainable energy strategies for the Balearic and Canary Islands, in collaboration with their respective autonomous and island governments, that will make it possible to reduce the energy cost overruns in these territories. In particular, these strategies will seek the appropriate territorial integration of renewables and the ability to supply firm power and other services, such as frequency stabilisation or black starts in the event of zero voltage, as well as emissions-free modes of transport and the integration of the change in the energy model into the water cycle.

d) Responsible bodies

General State Administration (MITECO, IDAE), autonomous island communities.

3.1.3 Emissions Trading Systems (ETS) sectors

The policies and measures in these sectors fall within the scope of Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814.

In Spain, the European emissions trading system is governed by Law 1/2005 of 9 March 2005, as well as by various Royal Decrees that develop this law. This system affects around **900 industrial and electricity generation installations** in Spain, as well as more than 30 active aircraft operators.

Furthermore, through the fourth Additional Provision of Law 1/2005, Spain has implemented Article 27 of Directive 2003/87/EC, which permits Member States to exclude small emitters and hospitals from emissions trading.

In 2011, Spain adopted Royal Decree 301/2011 of 4 March 2011, on mitigation measures equivalent to participation in the emissions trading system for the purpose of excluding small-scale installations, which permitted the exclusion of 174 installations over the 2013-2020 period.

Member States also have the option to implement another ETS mechanism relating to compensation for indirect costs. In Spain, the sixth Additional Provision of Law 1/2005 establishes that the Government may create a mechanism for the compensation of indirect costs. This mechanism was created via Royal Decree 1055/2014 of 12 December 2014. Aid is awarded pursuant to this Royal Decree based on the Commission guidelines on state aid in this area (2012/C 158/04). To date there have been two calls for aid applications: in 2015, EUR 4 million was allocated to compensate for indirect costs incurred in 2015; and in 2017, EUR 6 million was allocated to compensate for indirect costs incurred in 2016 (note the change to a year-end approach). In both cases, the funds available were under 10 % of the eligible costs in accordance with the Commission guidelines; however, the 2018 State Budget provides for additional compensation for successful tenderers from the second call. At the time this Plan is being drawn up, the third call is underway, for costs incurred in 2017, with a budget of EUR 6 million.

Finally, in Spain, the use of income from auctioning emissions allowances is set out in a legally-binding regulation. As such, the fifth Additional Provision of Law 17/2012 of 27 December 2012, on the State Budget for 2013 provides that this income must be used to finance electricity system costs related to the development of **renewable energies (for 90 % and up to EUR 450 million)** and other measures for combating climate change (for 10 % and up to EUR 50 million).

With the objective of achieving a 20 % reduction in greenhouse gases by 2030 compared to 1990 levels, the ETS sectors must contribute with a reduction of approximately 61 % compared to 2005.

The measures to be implemented in these sectors are contained in Section 3.1.2. above and under the energy efficiency dimension.

3.1.4 Non-ETS sectors

As indicated in the section on objectives, this Plan deals with the policies and measures required to contribute to the European objective with a reduction in greenhouse gases of at least **20 %** by **2030** compared to 1990 levels. These reduction efforts must be shared between sectors subject to the emissions trading system (ETS) (electricity generation, refineries and major industries) and non-ETS sectors that can, in turn, be subdivided into:

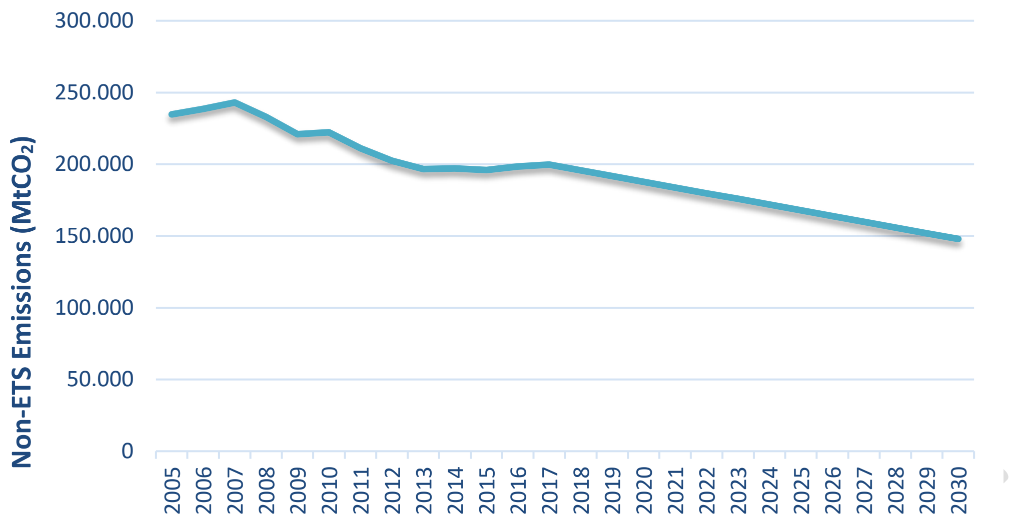
- Non-ETS energy; residential, commercial and institutional; transport, and non-ETS industry.
- Non-energy non-ETS; agriculture and livestock farming, waste management and fluorinated gases.

Furthermore, the gross emissions calculation must take into account the greenhouse gas emissions and removals resulting from land use, land-use change and forestry (LULUCF).

Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013, establishes binding objectives for each Member State for the reduction of greenhouse gas emissions in non-ETS sectors from 2021 to 2030. Accordingly, Spain must reduce its greenhouse gas emissions in non-ETS sectors by 26 % by 2030 compared to 2005.

However, if the target set by Spain of an overall reduction of 20 % is to be achieved, non-ETS sectors as a whole will have to contribute a reduction of **approximately 38 % compared to 2005** through the measures proposed. Within this group, the waste management, farming and fluorinated gas sectors (non-energy non-ETS) will contribute with reductions of approximately 28 %, 18 % and 33 % respectively, compared to 2005 levels.

Figure 3.2. Historic and projected emissions.



Source: Ministry for Ecological Transition, 2019.

This Regulation also defines the methodology for calculating and defining the linear reduction path that should be applied to establish the annual emissions allowances (AEAs) that each member state can issue annually. The emissions reporting cycle for inventories means that until 2020 it will be not possible to apply the methodology to data on non-ETS emissions that have been inventoried and verified. Consequently, the Member States' AEAs will not be set until then.

Furthermore, this Regulation establishes that if a Member State exceeds its annual emissions allowance it will be able to use an additional quantity up to the sum of total net removals and total net emissions of greenhouse gases from the combined accounting categories of afforested land, deforested land, managed cropland and managed grassland (LULUCF). The Regulation also establishes a set of requirements that must be met to be able to make use of this flexibility. **For Spain, the total amount that can be used throughout the period is 29.1 $MtCO_2$ eq.**

The specific and measurable policies in the **energy sectors** (both non-ETS and ETS) are described in the corresponding sections on renewables and energy efficiency.

It should be noted in this regard, as indicated above, that **transport/mobility will make a decisive contribution to the decarbonisation of the economy envisaged in this Plan.** This sector, after the electricity sector, will mitigate greenhouse gas emissions to the greatest extent, reducing emissions by **28 $MtCO_2$ eq** between the start of the Plan in 2021 and the end of it in 2030. Measure 2.1. under the Energy Efficiency Dimension (3.2) explains that as a consequence of the generalised implementation, from 2023, of central zones ('almendras' or 'almonds') in Spanish cities with more than 50 000 inhabitants, access to which will be increasingly restricted for the most polluting vehicles, we hope to achieve a modal shift affecting **35 % of passenger-kilometres currently travelled in conventional vehicles.**

As regards the identification and implementation of the measures outlined below for the **non-energy non-ETS sectors**, these measures were analysed using the M3E model described in Annex B.

Measure 1.14. Reduction of greenhouse gas emissions in the agricultural and livestock sectors

a) Description

a.1. Promoting arable crop rotation on unirrigated land.

This measure involves promoting arable crop rotation on unirrigated land, including legumes and oilseed, that could replace cereal monocultures.

Arable crops often form part of crop rotation systems and have traditionally been used to conserve and maintain the fertility of the soil, improve pest, disease and weed control, and to maintain the soil's moisture level. The introduction of leguminous plants into crop rotation systems delivers improved nitrogen levels in the soil, improving its structure and fertility. This means that subsequent crops require less nitrogenous fertilisers.

Therefore, growing legumes has a positive effect on climate change mitigation, as it reduces the emissions associated with the use and production of this type of fertiliser. Furthermore, in terms of adapting to climate change, it increases the resilience of the soil and crops and as such is an appropriate adaptive measure, particularly in unirrigated systems.

a.2. Adjusting the application of nitrogen to the needs of the crop.

The measure proposed involves drawing up a fertilisation plan that takes into account the needs of the crop, so that organic and inorganic fertilisers are used at the correct dosage and at the right time.

The fertilisation plan will include splitting applications, using products that help to control the release of the nutrients and reduce emissions, promoting organic irrigation and, wherever possible, encouraging localised irrigation techniques and optimising machinery use. Furthermore, the judicious use of manure and slurry will be promoted. This will form part of the Circular Economy Strategy as these materials will be reused in the production chain

Nitrous oxide (N_2O) emissions resulting from the improper use of fertilisers will be reduced.

a.3. Frequent emptying of slurry from pig housing

This measure involves frequently emptying the pits under the pens at pig facilities. Frequent emptying means emptying them at least once a month. The technique referred to involves clearing the pits at the end of the period or when they are full. Frequently emptying the pits reduces NH_3, CH_4 and N_2O emissions.

These improvements in the management of manure and slurry at housing for different categories of pigs and cattle will reduce the emissions produced inside the housing.

a.4. Covering slurry ponds

This measure involves covering slurry ponds at new pig and cattle facilities.

The quantity of methane generated by a specific manure management system is affected by the degree to which anaerobic conditions are present, the temperature of the system and the time that the organic matter is kept in the system.

Completely covering slurry ponds reduces NH_3 emissions and odours by more than 90 %.

a.5. Solid-liquid separation of slurry

The measure proposed involves the solid-liquid separation of slurry, with the solids being stored and the liquid fraction being emptied into uncovered anaerobic ponds in areas with a high concentration of livestock (pig and cattle). This liquid part will be used for irrigation, making use of its value as a fertiliser.

Solid-liquid separation, in addition to enabling better management of manure, will facilitate subsequent processing and reduce greenhouse gas emissions.

Storing the solid fraction has a lower methane conversion factor (MCF) than storing the liquid slurry, and the liquid fraction obtained has a lower volatile solids content compared with the original material which means that methane emissions are reduced.

a.6. Production of compost from the slurry solid fraction.

The measure proposed involves producing organic fertiliser (compost) using pig and cattle manure in areas with a high concentration of livestock.

During composting, aerobic bacteria oxidise ammoniacal nitrogen, reducing NH_3 emissions. Moreover, this process enables the waste to be stabilised by means of aerobic fermentation, which produces CO_2 (not taken into account in the final balance as it comes from biomass) and small quantities of CH_4 and N_2O in comparison with other techniques that produce more greenhouse gas.

The compost produced is an organic soil improver that boosts the fertility and condition of the soil, given that it helps to fix carbon in the soil.

Measures aimed at reducing stubble burning will also be adopted with the aim of reducing the harmful health effects of particulate emissions.

b) Mechanisms

Regulatory measures from the Ministry of Agriculture, Fisheries and Food and/or interventions under the Common Agricultural Policy (CAP) Strategic Plan.

c) Responsible bodies

Ministry of Agriculture, Fisheries and Food, jointly with the Autonomous Communities in accordance with the distribution of the relevant powers in Spain.

Measure 1.15. Reduction of greenhouse gas emissions in the waste management sector

a) Description

a.1. Domestic or community composting

This essentially concerns recycling bio-waste or the organic fraction of urban waste *in situ*, by means of domestic or community composting. This measure is aimed at families, schools or neighbourhood associations in rural, semi-urban and urban areas.

The implementation of the measure will involve distributing composters among the target population, as well as an awareness-raising/training campaign for the households and communities involved to ensure the measure’s success. As a result, it will be possible to avoid sending bio-waste to landfill, to reduce the collection frequency for the remaining fraction and to obtain high-quality compost.

a.2. Separate collection of bio-waste for composting

The target population of this measure is mainly semi-urban areas and certain urban areas. The universe for this measure is the total amount of organic material and vegetable waste produced by the population, both domestic and major producers, that is taken to landfill.

Implementing it will require a new strategy for the collection model, the upgrading of the fleet where applicable and the construction or redevelopment of composting plants depending on the population concerned. The reductions will be the result of redirecting bio-waste destined for landfill and reducing collection frequency.

a.3. Separate collection of bio-waste for biomethanation

This measure concerns the implementation of a separate bio-waste collection system, but in this case it will be taken to a biomethanation plant, for use as a biofuel. The target population is primarily urban, since plants with a capacity over 40 000 tonnes are being considered.

In this case the mitigation effect has two aspects, one in line with the previous points made in relation to the collection frequency and avoiding landfilling bio-waste, and another that concerns the saving achieved by using a renewable energy.

a.4. Reduction of food waste

The measure proposed involves developing the National Strategy 'More food, less waste', through eight areas of action that will help to reduce food waste at every link along the food production chain, achieving real changes in attitudes, procedures and management systems. These include, among other activities, information/awareness-raising campaigns to publicise guidelines on buying, storing and preparing food responsibly, voluntary agreements, reviewing legislation, developing guidelines and promoting RIC.

This measure is part of efforts to reduce the amount of waste generated. At the international level, as regards the Sustainable Development Goals, SDG 12.3 seeks to halve food waste at the consumer level and reduce food losses and waste during primary production, processing and distribution. The EU has developed a platform to drive the achievement of this goal, and it is also covered in the EU Action Plan for the Circular Economy. At the national level, the Ministry of Agriculture, Fisheries and Food, through the household food waste panel, calculated that 1 229 509 tonnes of food was thrown away in 2017.

a.5. Increase in the separate collection of paper at municipal level

This measure involves increasing paper collection and recycling at the municipal level (households, small businesses, HORECA, buildings, banks and offices). Although in general terms paper can be considered an organic fraction of solid waste, it should be considered separately for several reasons: it has its own collection channel, greater potential for selective collection and recycling and the potential to emit more methane than bio-waste.

Reductions will be achieved by avoiding sending the paper collected to landfill. Furthermore, the reductions derived from using recycled pulp instead of virgin pulp have been taken into account.

This measure involves the selective collection of paper at the municipal level with a particular focus on schools, universities and the administrations, by installing special containers and improving the amounts collected, with the aim of recycling the paper.

a.6. Increase in the separate collection of household used cooking oil

This measure centres around the separate collection of oil from households, as there is already an adequate level of implementation in hotel and restaurant services. Local authorities would be responsible for implementing a collection model adapted to their municipality.

Used cooking oil is a valuable secondary material for the manufacture of biodiesel. Consequently, this measure not only contributes to the reduction of emissions resulting from poor waste management, but it also offers other benefits such as contributing to the objectives relating to renewable energy and second-generation biofuels, and to reducing the risk of water and aquifer contamination.

a.7. Increase in the separate collection of textiles

Although some of this waste stream is collected separately for reuse and recycling, concerns around textile waste have led the EU to define an objective on the separate collection of this material. Textiles represent 6 % of the waste fraction taken to landfill in Spain and half of this amount comprises natural fibres.

This measure involves the separate collection of clothes and used textiles, via roadside containers or other facilities, for their reuse and recycling, thus avoiding their being taken to landfill where the natural fibres emit methane as they decompose. Often the implementation of such measures is also associated with other social benefits.

The universe has been estimated on the basis of the description of the waste fraction in the National Framework Plan for Waste Management (PEMAR) 2016-2022.

a.8. Management of biogas leaks from enclosed landfill

For a significant part of its history, waste management in Spain has consisted of landfilling. Consequently, there is a significant inventory of landfill sites that have been enclosed in accordance with legislation, but at which there are still a considerable number of biogas leaks. In these cases, the plan is to cover the surface of the landfill sites with an oxidising layer that contains methanotrophic bacteria able to oxidise the methane that passes through the layer. There are currently several methods that can be adapted to the characteristics of the target landfill sites. The measure involves applying oxidising layers to the surface of the target landfill sites, with the oxidation ratio by area estimated, conservatively, on the basis of studies and projects on the subject.

a.9. Use of woody pruning waste as biomass

This measure involves the use of pruning waste as biomass by cogeneration companies (electricity uses) or in the production of pellets (thermal uses), which will substitute the use of fossil fuels.

CH_4 and N_2O emissions caused by burning woody pruning waste will be reduced. Olive and vine are the main crops being considered given the large size of their growing areas and the size and volume of pruning waste that they produce.

This measure will also lead to a significant reduction in particulates and so contribute to the National Air Pollution Control Programme.

b) Mechanisms

Amendment of Law 22/2011, of 28 July, on waste and contaminated soils to accelerate the transposition of the amended Waste Framework Directive and bring forward the obligatory separate collection of bio-waste to before 31 December 2020 for municipalities with more than five thousand inhabitants and before 31 December 2023 for other municipalities.

Framework project for the regulation of end-of-waste criteria for compost and digestate, of domestic and community composting, and of the requirements for recovering organic waste to the soil using woody pruning waste.

Aid for Waste via the Environmental Promotion Plans (Planes de impulso al medio ambiente, PIMA) and the National Framework Plan for Waste Management (Plan estatal marco de gestión de residuos, PEMAR).

Draft Royal Decree to include a restriction on landfilling separately collected waste fractions, incorporating the obligatory nature established under Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018 amending Directive 1999/31/EC on the landfill of waste.

National strategy ‘More food, less waste’ (‘Más alimento, menos desperdicio’) 2017-2020, available at www.menosdesperdicio.es.

Strengthening the obligation to separately collect the materials for which separate collection was obligatory under Law 22/2011 of 28 July 2011 (paper, plastic, glass and metal) from places other than households, by reforming Law 22/2011 of 28 July 2011, in order to transpose Directive (EU) 2018/851 amending Directive 2008/98/EC.

Ministerial Order for the development of end-of-waste criteria for separately collected paper waste, and approval thereof.

Ministerial Order for the development of the criteria for determining when fatty acid methyl esters (biodiesel), produced from used cooking oil or animal fats for use as automotive biofuel or as a biofuel in heating equipment, cease to be waste.

Other regulatory measures from the Ministry of Agriculture, Fisheries and Food and/or interventions under the Common Agricultural Policy (CAP) Strategic Plan.

c) Responsible bodies

Ministry of Agriculture, Fisheries and Food and MITECO, jointly with the Autonomous Communities in accordance with the distribution of the relevant powers in Spain.

Measure 1.16. Reduction of fluorinated greenhouse gas emissions

a) Description

a.1. Replacement of facilities that use fluorinated gases that have a high Global Warming Potential (GWP) with other facilities that use gases that have a low or no GWP.

This involves the replacement of equipment that uses hydrofluorocarbons (HFCs) that have a high GWP (primarily refrigeration/air-conditioning equipment) with other alternative equipment that uses refrigerant gases that have a low or no GWP (CO_2, NH_3, hydrocarbons or fluorinated gases with a low

GWP such as R-32 or Hydrofluoroolefins (HFOs)). This measure affects the total existing HFC bank.

a.2. Reduction of HFC emissions through measures at existing HFC facilities

This involves reducing the emissions from existing facilities through measures that reduce HFC emissions linked to leaks from this equipment. The measures involve implementing periodic checks, automatic leak detection systems, retrofitting, redeveloping existing high GWP fluorinated gas facilities into compatible low GWP fluorinated gas facilities, and enclosing refrigerator units in commercial refrigeration establishments to reduce the quantity of fluorinated gases used.

a.3. Recovery and management of fluorinated gases at the end of the useful life of the equipment.

This involves recovering and managing fluorinated gases at the end of the useful life of equipment that uses them, prioritising their regeneration and recycling over other management options. Recovering the refrigerant gas and managing it properly will prevent the full quantity from being emitted into the atmosphere.

a.4. Promoting the use of mildly flammable refrigerants with a low GWP.

This involves reviewing the safety standards on refrigeration and climate control to make it possible to use A2L mildly flammable refrigerants with a low GWP (such as R-32 and HFOs) more extensively, particularly in the domestic air-conditioning sector. The universe covered by the measure is the sales of domestic air-conditioning units in Spain.

b) Mechanisms

- **Tax on fluorinated greenhouse gases** (Law 16/2013 of 29 October 2013, establishing certain measures in the field of environmental taxation and adopting other tax and financial measures).
- **Gradual reduction under a quota system** pursuant to Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006.
- **Royal Decree 115/2017 of 17 February 2017, governing the placing on the market and use of fluorinated gases** and equipment based on them, as well as the certification of the professionals that use them, which establishes the technical requirements for facilities conducting fluorinated gas emitting operations.
- **Voluntary agreement** for the more environmentally-friendly integrated management of the use of SF_6 in the electricity industry.
- Amendment of Royal Decree 138/2011 of 4 February 2011, approving the **Safety Regulation on refrigeration installations and their additional technical guidelines.**

c) Responsible bodies MITECO and the Ministry of Industry, Commerce and Tourism.

3.1.5 LULUCF (Regulation 2018/841)

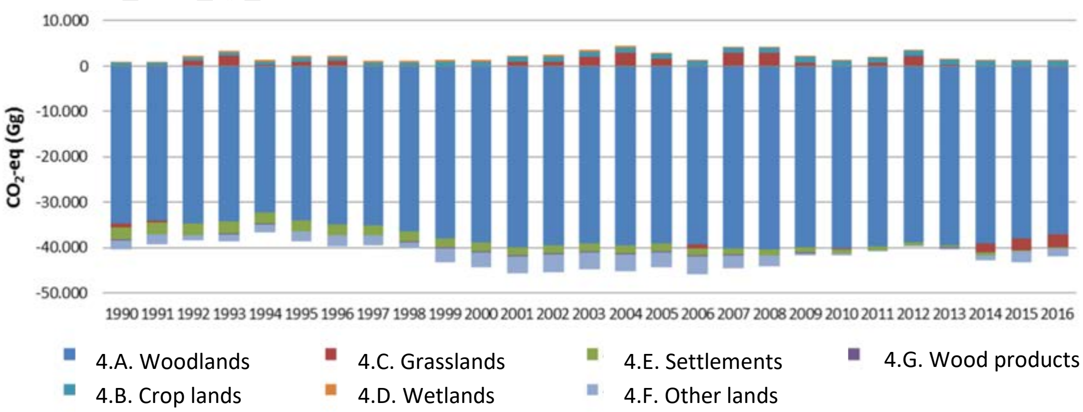
Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU establishes that, during the periods between 2021 and 2025 and between 2026 and 2030, each Member State must guarantee that emissions will not exceed removals, calculated as the sum of total emissions and total removals in their territory in the accounting categories of afforested lands, deforested lands, managed cropland, managed grassland, managed forest land and managed wetland (with the latter being obligatory from 2026).

It also establishes a mechanism for flexibility in achieving this objective, such that if a Member State's total emissions exceed its total removals in LULUCF, it may use its own AEAs or acquire another Member State's excess in LULUCF, provided that total emissions do not exceed the total removals at the European level. In the event that its total removals exceed its total emissions, the Member State may transfer the remaining amount of removals to another Member State.

This means that Spain must guarantee that emissions in this sector do not exceed removals during the 2021-2030 period. According to the accounting method approved by the Regulation, the contribution of the measures to removals in the LULUCF sector will be based on the forest reference level, which is currently being calculated, and which must be submitted to the European Commission no later than 31 December 2019 (for the period from 2021 to 2025). The Commission will, in turn, adopt a delegated act on the forest reference level applicable to Spain on 31 October 2020 at the latest.

In any case, the range of measures to be implemented will, as far as possible, enable Spain to achieve a positive removals balance in the LULUCF sector such that it will be able to **use up to 29.1 MtCO$_2$ during the 2021-2030 period to meet the objectives in non-ETS sectors.**

Figure 3.3. Emissions (+) and removals (-) of CO$_2$-eq by land use and land use change (LULUCF) over the 1990-2016 period



Source: Ministry for Ecological Transition, 2019.

Measure 1.17. Forest sinks

a) Description

a.1. Regeneration of silvo-pastoral systems.

Currently the main problem affecting the conservation of dehesas (shade tree and pasture systems) is the lack of regeneration of the dominant tree species. This is due to several causes such as overgrazing, the lack of planning in silvo-pastoral management, the excessive use of firewood, the excessive burden of game animals, forest fires, and the incidence over recent years of root rot and other factors that cause decay, colloquially grouped under the name dry rot. These factors have led the Spanish dehesas and other silvo-pastoral landscapes to be in a far from ideal state of conservation, with inadequate tree densities.

This measure aims to regenerate the dehesas and other open highlands so they can be considered silvo-pastoral systems and the full sink effect can be taken into account, with the dual purpose of maintaining these ecosystems, which are one of Spain’s main natural assets from a social, economic and environmental standpoint, and of avoiding CO_2 related costs and losses, both in tree biomass and in the soil.

a.2. Promoting poplars as replacements for agricultural crops in flood-prone areas.

This measure aims to promote the cultivation of black poplars, considering their importance for the national economy and their significant environmental contribution in terms of CO_2 removals, together with their significant potential to help stabilise riverbanks and their ability to withstand regular flooding and waterlogged soil. This last characteristic makes them an ideal crop for flood-prone areas in comparison with other crops. Furthermore, when they are located between agricultural land and riverbanks, they act as a natural water filter for surface runoff and surplus irrigation water containing fertilisers and plant protection products.

This measure will involve planting new poplar groves, in flood-prone areas with a return period of 10 years, based on the risk of floods originating in rivers to economic activity mapped by the National Flood-Prone Area Mapping System (SNCZI).

a.3. Creation of forest areas

Forests play a central role in the global carbon cycle given that they capture carbon from the atmosphere as they grow and store it in their tissues. Given their enormous biomass, forests are one of the biggest carbon sinks. They also produce goods and products that are of great importance to society (biodiversity, protecting the water cycle, jobs, products, etc.).

This measure involves promoting afforestation (the conversion, by direct human activity, of unforested land into forested land over a period of at least 50 years via planting, sowing or human-induced natural regeneration) and reforestation (the conversion, by direct human activity, of unforested land that was once woodland but is currently deforested into forested land via planting, sowing or human-induced natural regeneration).

a.4. Forestry activities to prevent forest fires

We currently have a forest environment that is very prone to fires and the means of extinguishing these fires are reaching the limits of their effectiveness. It is therefore vital that more attention be paid to preventive activities that help to reduce the risk of outbreaks and facilitate efforts to extinguish the fires.

This measure covers the work required to reduce and control the amount of wood fuel, making the forests more resistant to the outbreak and spread of fires and facilitating efforts to extinguish fires when they do occur. The amount of fuel is controlled by breaking the spatial continuity of vegetation, by means of scrub clearing, pruning, thinning, etc., particularly in areas where it is difficult to work with machinery.

Forest fires pose a variety of dangers in addition to the release of the carbon fixed in the biomass and the production of additional emissions (CH_4, N_2O, NO_x and CO) due to incomplete combustion, such as the release of organic carbon from the soil and the consequent erosion, or the public expenditure involved in putting out forest fires.

The working method is based on the application of techniques by specialised personnel who propose and apply specific and balanced measures that serve to control and improve the vegetation, while recognising the interests of the different groups present in the area.

a.5. Controlled grazing in strategic areas to prevent forest fires

This measure is also focused on the prevention of forest fires, but it proposes the integration of planned grazing into fire prevention efforts, as another complementary tool.

Controlled grazing in pastoral firebreaks is a sustainable farming practice in that the livestock help to reduce the risk of fire and play an important ecological function in Mediterranean forests. Furthermore, their inclusion in the range of forest management tools encourages the local population to be more vigilant and take more of an interest in forest conservation, promoting collaboration between experts and farmers, which strengthens the social prevention of fires.

Grazing in firebreak areas is, therefore, a useful fire prevention tool that offers very positive environmental and social externalities, making it, ultimately, a valuable land management system.

a.6. Promoting sustainable coniferous forest management, application of thinning schemes to increase carbon removals

Apart from increasing forest areas through planting and land use changes, it is possible to increase the biomass storage capacity of already established forest systems by applying particular management techniques.

Thinning, understood as the reduction of the density of individuals of the same species, is an intermediate forestry intervention that is essential in the management of forest systems. Its objectives include, in particular, reducing competition, improving the individual vigour of the trees, regulating the specific composition of the forest, anticipating and maximising production at the end of the cycle, and increasing the value and size of the products.

From the point of view of CO_2 fixation there is ample scientific evidence that, even though thinning reduces the number of trees in the forest, the application of specific schemes can increase the total amount of CO_2 removed by the forest throughout its productive cycle.

This measure promotes the development of management plans that include an adequate thinning plan, quantifying the improvement involved in terms of CO_2 removals, without quantifying other associated benefits (improvements in forest health, reduction in forest fires, etc.).

a.7. Hydrological-forest restoration in areas at high risk of erosion.

Hydrological-forest restoration incorporates the range of measures required to conserve, defend and recover the stability and fertility of the soils, regulate runoff, reinforce channels and slopes, contain sediment and in general defend the soil against erosion, all measures that seek to retain organic carbon in the soils and that have other synergistic effects such as defending against desertification, drought and flooding, conserving and recovering biodiversity and enriching the landscape.

This measure involves the construction of structures intended to correct and stabilise watercourses in areas at high risk of erosion (according to the map of desertification risk in the **National Action Plan to Combat Desertification**), but not the reforestation of this land as these types of activities are covered in a separate measure.

b) Mechanisms

- Interventions that may be developed as part of the upcoming CAP Strategic Plan in Spain.
- The inclusion, where applicable, of interventions in the third-generation River Basin Management Plans and the flood risk management plans.
- Harmonisation of the fees for the use of public water resources to incentivise poplar planting in designated areas.
- Promotion of public-private financing instruments aimed at boosting the creation of territorial contracts that could implement forest fire prevention measures.
- Analysis and study of the tax regime linked to forests to promote the active management of forest areas and consequently reduce the risk of forest fires.
- Promotion of public-private financing instruments aimed at stimulating the creation of territorial contracts that could implement measures to facilitate grazing in forest landscapes.
- Promoting intermediate forestry measures to better secure forest products with greater

added value and enable the energy recovery of forest waste.

- Development and implementation of the **Plan of Priority Actions for Hydrological-Forest Restoration**.
- Development and implementation of the **National Soil Inventory**.

c) Responsible bodies

Ministry of Agriculture, Fisheries and Food and MITECO, jointly with the Autonomous Communities in accordance with the distribution of the relevant powers in Spain.

Measure 1.18. Agricultural sinks

a) Description

a.1. Promoting conservation agriculture (direct sowing)

This measure involves applying conservation agriculture techniques that increase the amount of CO_2 removed by agricultural soils and reduce emissions from diesel-powered agricultural machinery. The measure will be applicable both in terms of mitigating and adapting to climate change, as it not only enables the soil to act as a carbon sink, thus mitigating climate change, but it also improves its resilience. Farmers will need to be trained for it to be implemented.

a.2. Maintenance of plant cover and the incorporation of pruning waste into the soil for woody crops.

This measure involves maintaining live plant cover between the crop rows and incorporating woody pruning waste into the soil. These two agricultural practices are compatible and synergistic.

Greenhouse gas reductions are achieved, on the one hand, by not tilling the soil, as is traditionally done, and on the other, by avoiding the uncontrolled burning of pruning waste. Furthermore, reducing emissions through these measures has agricultural benefits (by improving soil structure and productivity), environmental benefits (by increasing the amount of organic carbon in the soil and the associated biodiversity and by protecting the soil from erosion) and economic benefits (by reducing the amount of fertiliser required).

b) Mechanisms

Regulatory measures from the Ministry of Agriculture, Fisheries and Food and/or interventions under the Common Agricultural Policy (CAP) Strategic Plan.

c) Implementing public authorities

Ministry of Agriculture, Fisheries and Food, jointly with the Autonomous Communities in accordance with the distribution of the relevant powers in Spain.

3.1.6 ETS Sectors

Measure 1.19. European Emissions Trading System

a) Description

Greenhouse gas emissions in the electricity generation and basic industries sector will continue to be governed by the European emissions trading system. The latest reforms introduced by Directive (EU) 2018/410 of the European Parliament and of the Council strengthen this system, positioning it as a key measure for the European Union's achievement of its climate change objectives. In Spain, the European emissions trading system is governed by Law 1/2005 of 9 March 2005, as well as by various Royal Decrees that develop this law. This system affects around 900 industrial and electricity generation installations in Spain, as well as more than 30 active aircraft operators. Greenhouse gas emissions subject to this system make up around 40 % of the national total. Given that they are due to be applied from 2021, the national legislative framework will have to be adapted to the latest reforms.

b) Mechanisms

Law 1/2005, of 9 March, and Royal Decrees developing this law.

c) Implementing public authorities

MITECO.

3.1.7 Taxation

Measure 1.20. Taxation

a) Description

In line with the Change Agenda approved by the Spanish Council of Ministers held on 8 February, at which the need to 'adapt the tax system to the 21st Century' was expressed, as was the need for a 'new green approach to taxation - aligning taxation with environmental impact', the Ministry of Finance will lead an in-depth study and, where applicable, take the corresponding steps to update those elements of the tax system that could systematically incentivise a low-carbon and climate resilient economy, through the progressive and generalised internalisation of the environmental externalities that occur in the generation and use of energy, as well as in the execution of the main economic activities that emit greenhouse gases and increase the vulnerability of the Spanish economy to the foreseeable impacts of climate change.

3.2 DIMENSION ENERGY EFFICIENCY

3.2.1 Measures for compliance with the obligation to save energy. Sectoral approach

Article 7 of the Directive on Energy Efficiency (Directives 2012/27/EU and 2018/2002/EU of the European Parliament and of the Council) establishes the obligation to demonstrate cumulative final energy savings up to 2020 and 2030, with the latter calculated from 1 January 2021 until 31 December 2030, in accordance with the cumulative scheme applied in the Directive's first implementation period, from 1 January 2014 to 31 December 2020.

This cumulative savings target must be reached by implementing a system of energy efficiency obligations on energy providers or through the application of alternative measures of a regulatory, fiscal, or economic nature, or related to information and communication, which must be executed by the public authorities.

In this section of the INECP, we present the **ten principal energy efficiency measures** designed to meet the final energy saving obligation arising from the application of Article 7 of the Directive on Energy Efficiency.

Spain accepts the commitment of meeting this energy-saving target and proposes measures to ensure a uniform annual effort throughout the period in question, from 1 January 2021 to 31 December 2030, such that the mechanisms for action included in this Plan, as well as the public funding identified as necessary, have the goal of ensuring **the demonstration of new and additional final energy savings equivalent to 669 ktoe/year.**

The system of energy efficiency obligations is regulated in Spain through Law 18/2014 of 15 October 2014, approving urgent measures for growth, competitiveness and efficiency. This Law also created the **National Energy Efficiency Fund**, with no legal personality, as an instrument for implementing mechanisms for financial and economic support, technical assistance, training and information, and other measures intended to increase energy efficiency across all sectors. The National Energy Efficiency Fund will extend its remit to **31 December 2030**, in accordance with the approved Energy Efficiency Directive review.

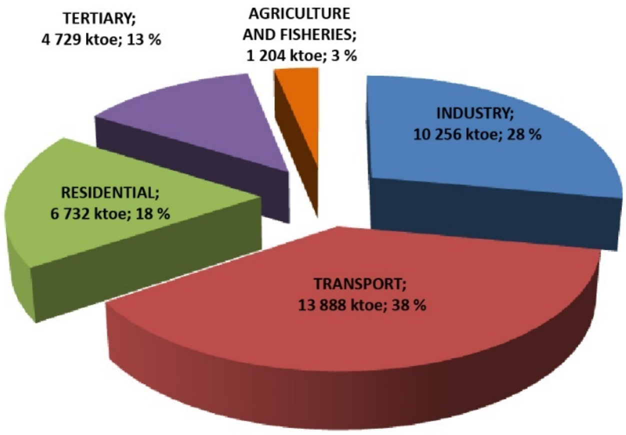
In addition to the mechanisms that could be developed with the resources of the National Energy Efficiency Fund, the Target Scenario of this Plan considers **regulatory and fiscal mechanisms** to enable the greatest and fastest market penetration of efficient technologies, the greatest electrification of transport and energy demand in construction, the active participation of demand in managing the energy system, self-consumption and distributed generation, and also a greater contribution of thermal renewable energies to the coverage of final energy demand.

In particular, it highlights measures for energy efficiency and energy saving in the rail, maritime and air transport sectors, not considered in the measures developed with the resources of the National Energy Efficiency Fund. As a result of the investments considered in the Infrastructure, Transport and Housing Plan (PITVI) 2012 – 2024 et seq. of the Ministry of Public Works, greater energy efficiency will be promoted for the conventional rail system, to make it more efficient and competitive, and directing it towards covering the requirement for the daily transport of people and goods, as far as possible. In parallel, energy efficiency measures will be promoted for air and maritime transport.

The Ministry of Finance will lead an exhaustive analysis on the potential complete review of the environmental tax policy of Spain. There is a general consensus that it is an instrument with great potential to facilitate the transition to a low-carbon economy. The fundamental objective is the internalisation of the negative externalities derived from the use of certain fuels or technologies, so that in the decision-making process the energies or technologies with the lowest environmental impact are selected. This review of environmental tax policy will enable Spain to move rigorously and efficiently towards an environmentally sustainable economic model.

The plan presents **10 energy efficiency measures** that have been designed, taking a **sectoral approach**, with the aim of meeting the energy-saving obligation arising from Article 7 of the Energy Efficiency Directive. The transport sector is highlighted, with four measures that will significantly contribute to the cumulative final energy saving target for the 2021-2030 period, with almost 14 Mtoe of savings. The transport sector is followed by the industrial and residential sectors, with 10 Mtoe and 6.7 Mtoe of savings respectively. The services sector and agriculture and fishing are those with the lowest contribution, with 4.7 Mtoe and 1 Mtoe respectively:

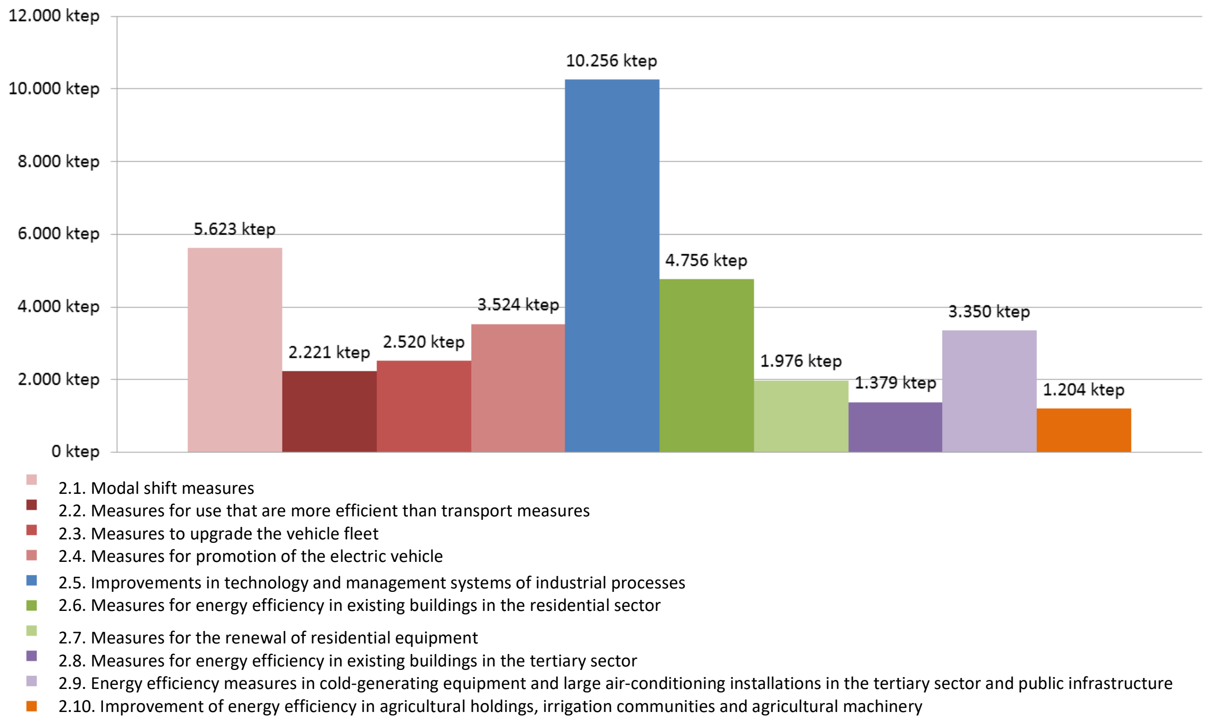
Figure 3.4. Cumulative final energy saving by sector in Spain 2021-2030 (ktoe)[39]



Source: Ministry for Ecological Transition, 2019.

[39]The quantification of energy savings included in this chapter includes those necessary to ensure compliance with the energy-saving target associated with Article 7 of the Energy Efficiency Directive, formulated in terms of cumulative final energy saving from 1 January 2021 to 31 December 2030. Spain agrees to meet this cumulative energy-saving target, which will be translated into a greater or lesser volume of annual savings in each of the financial years, depending on whether the energy-saving and energy-efficiency measures are concentrated in the first or second half of the decade. The objective of decarbonisation of the Spanish economy by 2050 will require increased enforcement of energy-saving and energy-efficiency measures, particularly with regard to transport and the reduction of traffic in urban and inter-urban environments, with regard to the cumulative energy-saving target of Article 7.

Figure 3.5. Cumulative final energy saving by measure in Spain 2021-2030 (ktoe)



Source: Ministry for Ecological Transition, 2019.

In addition, we must consider that these sectoral measures are complemented by the horizontal and financial measures defined in sections 3.2.2 and 3.2.4 below.

Transport sector

Measure 2.1. Modal shift measures (promoting more efficient modes of transport).

a) Description

The objective of this measure is to reduce final energy consumption and carbon dioxide emissions by acting on urban and metropolitan transport, to achieve significant changes in modal distribution, with greater use of the most efficient modes of transport, and less use of private vehicles with low occupation, encouraging shared use, as well as modes of transport that do not consume energy, such as walking and cycling.

The measure is intended to reduce the use of private vehicles, as the Target Scenario of this INECP considers it possible to reduce passenger traffic (passengers/km) in urban environments by 35 % by 2030, and to reduce inter-urban transport by approximately 1.5 % annually; remote working, shared vehicles, the use of non-motorised vehicles and shared public transport will enable these targets to be achieved.

The main driving force behind the modal shift is the **general application from 2023 in all towns and cities with more than 50 000 inhabitants of the delimitation of central zones with limited access for the most polluting vehicles with the highest emissions.** This measure, one arising from this Plan, aims to transform towns and cities to ensure greater quality of life by improving air quality. The measure includes a wide range of actions of different types to enable the investment in infrastructure that will enable the necessary modal shift to take place.

In this respect, this measure is defined with a wide remit, beyond the scope of the actions that have been implemented since 2015 under the charge of the National Energy Efficiency Fund. In this Plan, the participation and coordination of all the Regional Administrations, and also the support of private initiatives and financial entities in particular, are fundamental for raising investment. Therefore, the drive to develop legislation in the Autonomous Communities with regard to transport, in coordination with the bases established at national level, will be one of the priorities.

Specifically, its execution will be promoted through the design of public funding programmes for the measures contained in the **Sustainable Urban Transport Plans** which must be implemented by the local authorities (with the support of other Regional Administrations, and where applicable, the General State Administration) and the **Transport for Work Plans** implemented by companies.

This measure is consistent with the sustainable transport priorities established in Articles 102 and 103 of the Sustainable Economy Law 2/2011.

b) Expected cumulative and annual energy savings for each measure and/or quantity of energy savings in relation to any intermediate period

The target for this measure is **5622.9 ktoe of final energy savings** accumulated in the 2021-2030 period, of a total of 13 888 ktoe, which represents the total for the transport sector.

c) Responsible Bodies

The public authorities responsible for the execution and follow-up of the measure will continue to be the Ministry for Ecological Transition (MITECO)/Institute for Energy Saving and Diversification (IDAE) (coordinated with other Ministerial Departments responsible for transport-related matters), together with the Autonomous Communities, and in particular, the local authorities.

d) Target sectors

This measure is aimed at town and city councils, regional councils, and other extra-municipal bodies for regional representation, as well as public or private workplaces and companies or activity centres (airports, train stations, industrial complexes, education or health centres, universities, leisure parks, shopping centres, etc.). It is also aimed at transport authorities and companies, as well as logistics centres.

e) Eligible actions

Eligible actions are those which achieve a reduction in CO_2 emissions and final energy consumption, by means of significant changes in modal distribution through:

- the implementation and development of Sustainable Urban Transport Plans, with measures such as the delimitation of central urban zones with restricted access, pedestrianisation, traffic restrictions at high-pollution times, the promotion of vehicle sharing and the use of bicycles, improvement and promotion of public transport, etc.;
- the implementation and development of Transport for Work Plans, with measures such as shared transport services within companies, the promotion of bicycles, public transport, remote working, etc.

f) Mechanisms

The mechanisms for action that will enable the planned energy-saving targets to be achieved are as follows:

Legislative measures: the future Law on Climate Change and Energy Transition. Modification of Article 103 of the Sustainable Economy Law 2/2011 ('Development of Transport Plans in Companies'), requiring their implementation in companies with more than 250 employees (large companies) and the creation within these companies of the role of Transport Coordinator, in order to increase the number of companies with a Transport for Work Plan.

Other legislative measures include those which implement the corresponding Autonomous Community laws on transport within the scope of their powers, as well as municipal regulations, particularly among communities with more than 50 000 residents, with regard to restrictions on private transport, parking management, shared vehicles, traffic calming, traffic lanes reserved for public transport and other measures intended for sustainable transport.

Public support programmes: programmes to promote the implementation of the measures and actions contained in the Sustainable Urban Transport Plans and the Transport for Work Plans; the design of financial instruments to raise the necessary investment in rail infrastructure, to move the transport of goods from road to rail. In this regard we propose going beyond the target of the Infrastructure, Transport and Housing Plan (Plan de infraestructuras, transporte y vivienda, PITVI) 2012 - 2024, so that the switch from road to rail for the transport of goods is 7.5 % rather than 6 %.

Information: preparation and update of guides and manuals on sustainable urban transport; maintaining a platform aimed at citizens and transport managers on the IDAE website, which includes these guides, as well as useful information to promote the implementation of the Sustainable Urban Transport Plans and the Transport for Work Plans; developing and strengthening observatories, forums and round tables on sustainable transport.

Communication: conducting specific communication and information campaigns to support this modal shift and the rational use of private vehicles for urban travel; developing and promoting institutional campaigns for the promotion of public transport and support for new sustainable transport, including the granting of awards and commendations to exemplary projects.

g) Financial requirements and public funding

The financial requirements of this measure are high, with an estimated total cost of **€10 753 million** associated with the execution and launch of the measures contained in the Urban Transport Plans for large towns and cities and an additional **€3753 million for small towns** (fewer than 50 000 inhabitants). Together with this, the investment necessary to enable a successful modal shift and the transformation of the urban model is estimated to be **EUR 14.505 billion over 10 years** (to which a significantly smaller amount must be added - around EUR 265 million - for the implementation of Transport for Work plans in companies).

The actions included in the Sustainable Urban Transport Plans will be achieved from the public finances of the relevant administrative bodies (where applicable, taking the framework of the national and European programmes into account) and in the case of Transport for Work plans, public spending is estimated to be 50 % of the investment, equivalent to EUR 132.5 million.

Measure 2.2 Measures for more efficient use of means of transport

a) Description

The objective is to reduce final energy consumption and carbon dioxide emissions by promoting actions for the more rational use of the means of transport, including improved management of vehicle fleets on the roads, implementing efficient driving techniques for professional drivers (with potential fuel savings of around 10 %) and standardising loads and dimensions for the transport of goods by road to surrounding countries.

This measure is consistent with the Infrastructure, Transport and Housing Plan 2012 - 2024, of the Ministry of Public Works, which seeks to improve the energy efficiency of the conventional rail system, motivated by technological advances and for better use of energy, as well as promoting energy efficiency measures for air and maritime transport.

b) Expected cumulative and annual energy savings for each measure and/or quantity of energy savings in relation to any intermediate period

The target for this measure is **2 221.4 ktoe of cumulative final energy savings** in the 2021-2030 period, of a total of 13 888 ktoe which represents the total for the transport sector.

c) Responsible Bodies

The public authorities responsible for the execution and follow-up of the measure will continue to be MITECO/IDAE, together with the Autonomous Communities, following a model of joint management and joint financing of the measures and actions for energy efficiency that respects the distribution of the relevant responsibilities in Spain.

d) Target sectors

This measure is aimed at companies and public and private bodies with vehicle fleets for road transport of people or goods, or public works and services vehicles.

e) Eligible actions

Eligible actions include the application of energy audits to vehicle fleets, the installation of centralised technology systems and applications intended to improve efficiency and the delivery of fleet management courses for staff, as well as training for professional drivers in efficient driving techniques for industrial vehicles.

Legislative measures: adoption of the necessary regulations to standardise the loads and dimensions of national lorries with those of surrounding countries. **An increase in the maximum authorised load to 44 tonnes, with a height of 4.5 m, will enable an increase in the average loads of these vehicles of 10 % from 2021**, with a consequent reduction in the number of vehicles per kilometre and consumption per load carried.

Public support programmes: programmes of aid through grants aimed at companies.

Voluntary agreements: agreements signed with sectoral associations and accreditation of companies with efficient fleet management systems.

Communication: development of demonstration and promotion activities aimed at companies.

f) Financial requirements and public funding

The measure aims to raise a total investment amount of EUR 73 million, with EUR 22 million of public funding.

Measure 2.3 Measures to upgrade the vehicle fleet

a) Description

The objective of this measure is to improve the energy efficiency of the vehicle fleet by promoting the upgrade to more energy-efficient vehicles. The average age of vehicles is around 12 years. New vehicles on the market, regardless of their power source, are more efficient, and therefore their addition to the fleet gradually reduces overall consumption. By encouraging the purchase of more efficient vehicles, savings will be made in addition to those obtained through natural replacement of the vehicle fleet.

b) Expected cumulative and annual energy savings for each measure and/or quantity of energy savings in relation to any intermediate period

The objective of the measure is a saving in addition to that arising from the natural replacement of the vehicle fleet (considered in the projections of the Baseline Scenario included in this INECP) equivalent to **2519.6 ktoe of cumulative final energy savings** during the 2021 - 2030 period, of a total of 13 888 ktoe, which represents the total for the transport sector, by promoting the upgrade to more efficient vehicles. In the case of passenger cars, vehicles classified as A or B in the IDAE energy classification will be specially promoted. In the remaining categories, we will try to ensure that only vehicles that achieve a minimum proven reduction in average annual CO_2 emissions of 25 % benefit from the possible measures.

c) Responsible Bodies

The public authorities responsible for the execution and follow-up of the measure will continue to be the Ministry of Finance and the local authorities responsible for the management of the current ‘Tax on Motor Vehicles’ (Impuesto sobre Vehículos de Tracción Mecánica, IVTM) and the Special Tax on Certain Means of Transport or ‘registration tax’ (Impuesto Especial sobre Determinados Medios de Transporte, IEDMT).

d) Target sectors

This measure is aimed at the general public and companies with vehicle fleets.

e) Eligible actions

The purchase of more efficient vehicles.

f) Mechanisms

Taxation: The Ministry of Finance, in collaboration with the local authorities, in the budget line already initiated by the General Tax Directorate, will analyse the convenience, viability and time periods for reform of the current Tax on Motor Vehicles, levied by the local authorities, which records the ownership of vehicles suitable for circulation, based on fiscal horsepower, depending on the type and number of cylinders of the vehicle. This Plan considers it necessary to re-orientate the weighting of current amounts with criteria based on the emission of pollutants, which could be based on the European Standard or the environmental ratings of the Directorate General for Traffic, to penalise older vehicles, which generate more emissions and pollution.

At the same time, the Ministry of Finance will analyse the potential reform of the Special Tax on Certain Means of Transport so that the purchasing decisions of consumers are directed towards lower-consumption vehicles, which would be achieved by updating the current CO_2 emission guidelines on which this tax is based.

Legislative measures: In coordination with the Local Authorities, we will promote the application of traffic restriction and parking management measures on public highways by Local Councils, so that the oldest vehicles, which have the highest fuel consumption and pollution emissions, will be penalised.

g) Financial requirements and public funding

The total related investment, by individuals and companies, is estimated to be EUR 76.68 billion[40] for the 2021-2030 period.

Measure 2.4. Measures to promote electric vehicles

a) Description

The objective of this measure is to reduce the energy consumption of the vehicle fleet through electrification, enabling greater use of renewable energies in the transport sector. The current use of electric vehicles is very low (31 341 vehicles in 2017, including battery electric vehicles, plug-in hybrid electric vehicles, and long-range electric vehicles) and increasing their number will provide a series of advantages for manufacturers, in terms of compliance with the CO_2 reduction targets of EU regulations, compliance with the urban air quality requirements indicated in Directive 2008/50/EC of the European Parliament and of the Council, reduced dependency on petroleum derivatives, and improved demand management by acting on the curve of electricity system charging.

The mass electrification of vehicles will only be obtained when price parity is reached between electric vehicles and motor vehicles. According to manufacturers' estimations, this parity could be reached by 2025, due to the expected reduction in the price of batteries. This measure and measure 2.2 establish the basis for new passenger cars and light commercial vehicles, excluding those registered as historic vehicles not intended for non-commercial use, to gradually reduce their emissions, so that no later than 2040, they will be vehicles with emissions of **0g CO_2/km,** in accordance with European regulations.

On the other hand, it is estimated that by 2030, a significant percentage of electric vehicles will be used through Mobility as a Service (MaaS), supporting the transition from a culture of vehicle ownership to a service culture.

b) Expected cumulative and annual energy savings for each measure and/or quantity of energy savings in relation to any intermediate period

This measure will provide annual energy savings proportional to the number of electric vehicles introduced to the vehicle fleet, which will be done gradually. The Target Scenario of this INECP considers that we will reach **a vehicle fleet of 5 million by 2030** (passenger cars, vans, buses and motorcycles), which will lead to estimated **cumulative final energy savings of 3 524.2 ktoe/year** for the 2021-2030 period, of a total of 13 888 ktoe represented by the entire transport sector.

c) Responsible Bodies

The public authorities responsible for the execution and follow-up of the measure will continue to be MITECO/IDAE (in coordination with other Ministerial Departments, in particular the Ministry of Industry, Commerce and Tourism) together with the Autonomous Communities, following a model of joint management and joint financing of the measures and actions for energy efficiency that respects the distribution of competences in Spain. The local authorities will be administrative bodies contributing to the measure as a consequence of the application of their responsibilities for urban air quality control.

d) Target sectors

This measure is aimed at the general public and companies with vehicle fleets.

e) Eligible actions

The eligible actions for this measure include:

[40]The total related investment was calculated taking the total amount of new vehicles into account.

- The purchase of new electric vehicles.
- The deployment of recharging infrastructure for electric vehicles.

f) Mechanisms

The mechanisms for action that will enable the planned energy-saving targets to be achieved are as follows:

Public support programmes: programmes of aid through grants that multiply the budgets available under the previous programmes (MOVELE, MOVEA, MOVALT, MOVES) to individuals and companies for the purchase of electric vehicles. The General State Budgets for 2017, additional provision seventeen (‘Financing of actions to support energy-efficient and sustainable transport’) indicates that, with effect from 2017 and for an indefinite period, the Government is authorised to establish a system of aid for actions in support of transport based on criteria of energy efficiency, sustainability and promotion of the use of alternative energy, including the creation of appropriate energy infrastructure; this authorisation has enabled the allocation, both in 2017 and in 2018, of EUR 50 million annually to incentivise measures related to more sustainable transport, including the purchase of electric vehicles and the necessary recharging infrastructure, both public and private.

The budgets provided by the Autonomous Communities and local authorities will be added to this budget with the objective of incentivising the purchase of less polluting vehicles and the deployment of recharging infrastructure.

Taxation: the Ministry of Finance will analyse the suitability and viability of the potential reform of the Special Tax on Certain Means of Transport (‘registration tax’) to update the thresholds of CO_2 emissions on which the tax is based[41].

The reform would bring forward the date of price parity between combustion vehicles and electric vehicles, which would contribute to accelerating the use of electric vehicles beyond the requirements of the Regulation on CO_2 emissions for passenger vehicles and light vans, encouraging citizens to purchase zero-emission vehicles.

Communication: design of an ad hoc communication strategy focused on providing information on electric vehicles, the price and location of recharging points, the supply and provision of vehicles, etc. This strategy will use the communication channels with the greatest impact, specialised or non-specialised: The MITECO Geoportal, web platforms, smartphone applications, social networks, workshops and events.

g) Financial requirements and public funding

The total investment associated with the use of electric vehicles will be approximately EUR 132.403 billion[42]. The estimated public financial support to develop this measure in the 2021-2025 period, based on an aid budget line of **EUR 200 million/year in the 2021-2025 period (with funds from the General State Budgets and from the Autonomous Communities) is EUR 1000 million.** In the 2025-2030 period, it is estimated that price parity will have been reached and no public funding will be required.

[41] 74 % of vehicles currently registered are not liable for this tax as they are not over the limit of 120g CO_2/km.

[42] The total related investment was calculated considering the **total amount of new vehicles**. This concept is **not used in the economic impact evaluation of the INECP** (see chapter 4). The stated evaluation only considers the difference between the investment made in a conventional vehicle when it is replaced (Baseline Scenario) and the investment made under the Plan's Target Scenario when purchasing an electric vehicle (more expensive than the previous one). This difference is considered to be the ‘economic impact of the Plan’ and obviously it is a much lower quantity than that obtained by considering the total cost of the new vehicle.

Industrial Sector

Measure 2.5. Improvements in the technology and management systems of industrial processes

a) Description

This measure aims to facilitate the use of final energy saving technologies, mainly in small to medium enterprises (SMEs) and large companies in the industrial sector, particularly for facilities not included in the EU emissions trading scheme (EU ETS). This measure will improve the energy efficiency of industrial processes and guarantee final energy savings (and consequently, significant reductions in GHGs), thanks also to the implementation of energy management systems.

Firstly, the measure will promote the achievement of a greater volume of investment in the replacement of industrial equipment and facilities with poor energy performance by highly energy-efficient equipment and facilities, or directly with the Best Available Technologies (BAT); it will also consider the replacement of auxiliary energy-consuming systems. Secondly, it will also promote the achievement of a higher number of investments in the implementation of energy management systems in industry. These systems should include activities for measuring energy consumption variables and the installation of features to monitor and control process parameters, as well as the implementation of IT systems for analysis, monitoring and control. The aim is to achieve optimal functioning of the facilities, reduce energy consumption and costs, and provide information rapidly and precisely, which is necessary to improve the energy management of industrial facilities. In all cases, the energy management systems should comply with the UNE-EN ISO 50001 Standard on energy management systems or a substitute for this where applicable.

This measure was designed in relation to the energy efficiency promotion programmes for the industrial sector implemented in Spain under the National Energy Efficiency Fund, from May 2015 to the end of 2018, managed by IDAE in its role as the managing body for the Fund (Law 18/2014 of 15 October 2014).

The improved energy efficiency of equipment, systems and industrial processes is another objective in addition to those included in this INECP, which aims to achieve the energy transition while ensuring an improvement in competitiveness and employment. The programmes to promote industrial competitiveness that were implemented during the previous implementation period of Directive 2012/27/EU of the European Parliament and of the Council, using the method of repayable loans, on behalf of the Ministerial Departments with responsibility for industrial policy, have directed public aid to production processes that are advanced, efficient and environmentally friendly, in a way that is consistent with the energy and climate strategy and has synergy with the measures to promote the use of renewable energy sources in industry.

Raising new investment in equipment, systems and processes and implementing energy management systems in the form described, as a consequence of authorised public funds, will lead to new and additional final energy savings in the industrial sector during the new implementation period of the Energy Efficiency Directive, which corresponds to the period covered by this INECP. The public funds will either come from the National Energy Efficiency Fund, which until now has basically included the financial contributions of the energy providers, or from the General State Budgets or European funds.

In this last case, these public budgets can be directly channelled to the promoters or industrial companies through ad hoc programmes or through the National Energy Efficiency Fund, which can be used as a priority intervention tool in the public sector to raise investment in energy efficiency.

b) Expected cumulative and annual energy savings for each measure and/or quantity of energy savings in relation to any intermediate period

The measure aims to achieve **10 256 ktoe of cumulative final energy savings** during the 2021 - 2030 period.

c) Responsible Bodies

The public authorities responsible for the execution and follow-up of the measure will continue to be MITECO/IDAE (in coordination with other Ministerial Departments with responsibility for industrial policy) together with the Autonomous Communities, following a model of joint management and joint financing of the measures and actions for energy efficiency that respects the distribution of competences in Spain.

d) Target sectors

This measure is aimed at companies in the industrial sector, preferably manufacturing, as well as energy providers that make investments on behalf of clients within this sector.

e) Eligible actions

The eligible actions include those which achieve a reduction in CO_2 emissions and final energy consumption, by improving technology in industrial equipment and processes and implementing energy management systems.

By analogy with the implementation programmes in the previous period of Directive 2012/27/EU, actions considered to be economically 'non-viable' will not be eligible, meaning any actions where the period for basic return on the eligible investment is longer than the life span of the installation implemented.

f) Mechanisms

The mechanisms for action that will enable the planned energy-saving targets to be achieved are as follows:

Public support programmes: programmes of aid through grants or repayable low-interest loans within the framework of Community regulations on state aid.

Voluntary agreements: voluntary agreements signed with representative associations in sub-sectors with more intense energy use can promote the more rapid adoption of efficient technologies in the industrial sector.

g) Specific measures or individual actions on energy poverty

Not applicable.

h) Financial requirements and public funding

The total related investment is estimated to be **EUR 7.37 billion, with public funding of EUR 1.647 billion.**

Residential Sector

Measure 2.6. Measures for energy efficiency in existing buildings in the residential sector

a) Description

The measure aims to reduce the energy consumption of existing residential buildings used for housing through energy upgrade activities. The upgrade should enable the building's energy rating to be improved. This measure must be entirely consistent with the **Long-term building renovation strategy,** developed by the Ministry of Public Works, which will be updated in 2020, in compliance with Article 2 bis of Directive 2010/31/EU of the European Parliament and of the Council and the **State housing plan**, which is the basic tool for promoting urban and rural regeneration and renewal, which has been executed in collaboration with the Autonomous Communities.

This INECP considers that the energy efficiency certification of buildings (Royal Decree 253/2013, of 5 April 2013) constitutes a very useful tool for the promoters of upgrade activities with regard to new investments in existing buildings, whatever their use. However, and insofar as improving the energy rating of buildings can be achieved by acting on their thermal envelope or on the thermal facilities for heating and/or air-conditioning and domestic hot water (DHW), this Plan prioritises investment in the thermal envelope (facades, roofs and walls) with regard to improving the thermal facilities, considering that the reduction in thermal demand should first be addressed in order to avoid over-sized heating and/or air-conditioning equipment to meet that demand.

The description given of the measure takes the **Programme of aid for the energy upgrade of existing buildings** as a reference point. It was launched in Spain in October 2013 under the title of the PAREER programme, extended in May 2015 as PAREER-CRECE, and in force until 2018 under the title PAREER II. This programme is considered to have been a successful experience, precisely due to the fact that more than 85 % of the funds channelled to energy upgrade projects have been for actions to improve the energy efficiency of the thermal envelope (PAREER-CRECE). This programme may be promoted in the new implementation period of Directive 2012/27/EU due to the existence of **upgrade offices** in certain regions which identify projects and provide technical assessment to communities and owners to develop proposals. Public aid through grants and financing is then provided for the part not covered by the subsidies.

The basis of public funding will be the energy efficiency certificate of the building, which must contain a description of the energy features of the building as a starting point for conducting an energy diagnostic. This certificate will contain information on all the features subject to intervention from an energy perspective (thermal envelope, thermal facilities for heating, air-conditioning and domestic hot water, lighting and monitoring and management systems), as well as information on the normal conditions of operation and occupation, the conditions for thermal comfort and indoor air quality, etc.

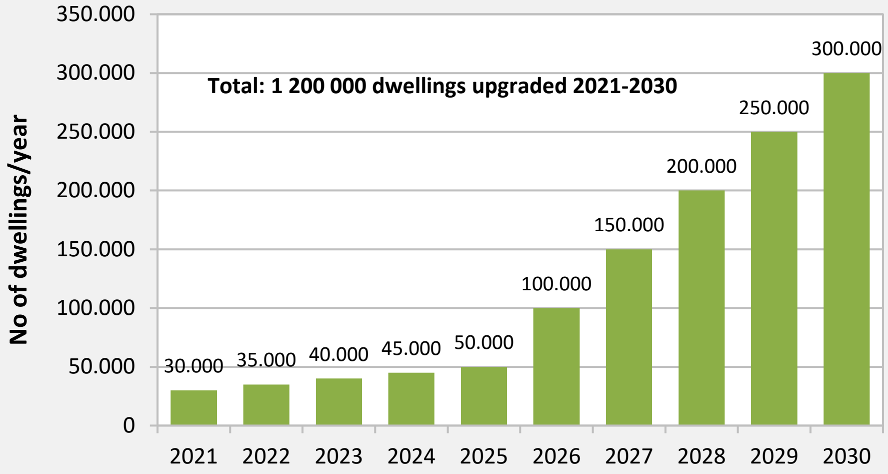
Each certificate should include recommendations to improve the optimal or profitable levels of energy efficiency of the building, or part of it, which can include an estimate of the time periods for the return on investment during their life span.

b) Expected cumulative and annual energy savings for each measure and/or quantity of energy savings in relation to any intermediate period

The measure aims to achieve **4 755.9 ktoe of cumulative final energy savings** during the 2021 - 2030 period. These savings will be the result, firstly, of acting **on the thermal envelope of 1 200 000 homes** throughout the period, starting with 30 000 homes/year in 2021 and finishing with 300 000 homes/year by 2030. This quantitative planning is indicative and the decisive factor for the targets of this Plan is the total energy savings achieved. The exact ratios for the upgrading of homes that will be undertaken for each area will be defined precisely in the future **Long-term strategy for energy upgrading in the building sector in Spain,** which is the responsibility of the Ministry of Public Works.

Secondly, of **the renovation of thermal facilities (centralised and personalised) in more than 300 000 homes per year.**

Figure 3.6. Annual indicative preview of homes with an energy upgrade 2021-2030



Source: Ministry for Ecological Transition, 2019.

c) Responsible Bodies

The public authorities responsible for the execution and follow-up of the measure will continue to be the Ministry of Public Works and MITECO/IDAE, together with the Autonomous Communities, following a model of joint management and joint financing of the measures and actions for energy efficiency that respects the distribution of competences in Spain.

d) Target sectors

The beneficiaries of this measure will be the owners of existing buildings for housing purposes, whether they are legal or natural persons, public or private, communities of owners or groups of communities of owners of residential buildings for housing purposes, or companies which operate, lease or hold concessions for residential buildings for housing purposes, and in all cases, the energy providers.

e) Eligible actions

Eligible actions will be those which achieve a reduction in CO_2 emissions and final energy consumption, by improving the services that take a greater share in the energy consumption of buildings, such as heating, cooling and the production of domestic hot water:

- **Thermal envelope**: action will be taken on the thermal envelope of buildings to achieve a reduction in demand for the heating and cooling of buildings. The energy efficiency actions may be applied to facades, roofs, floors, external woodwork, windows and solar protection, etc.
- **Thermal facilities**: action will be taken on the thermal facilities for heating, air-conditioning, production of domestic hot water and ventilation, governed by the Regulation on the Thermal Facilities of Buildings. The measure is about including renewable energy sources to meet demand, in accordance with the targets for final renewable energy consumption considered in this Plan.

  As a guideline, the actions may include, but are not limited to, the following:

  - the replacement of equipment for the production of heat and cold, and the transport of heat-carrying fluids, including upgrading of the thermal insulation of networks of pipes and appliances, to reduce losses in the transport of fluids;
  - the installation of systems of cost-free cooling from external air and of heat recovery from extracted air;
  - systems of automation and/or control and regulation of equipment and/or facilities, for energy-saving purposes, as well as systems of accounting for and remote management of energy consumption;

- new installations of centralised systems of urban or district heating and cooling, or systems which serve several buildings, as well as the upgrading and extension of existing systems.

f) Mechanisms

The mechanisms for action that will enable the planned energy-saving targets to be achieved are as follows:

Taxation: we propose that Ministry of Finance leads an exhaustive analysis of taxation in the residential sector, with the goal of internalising the positive externalities that would result from improving the energy efficiency of buildings in relation to this sector.

Legislative measures: the transposition into national legislation of the new requirements for energy efficiency and renewable energies established by the new European Directives for new and existing buildings in the residential sector will be a necessary condition for the success of the planned support and financing programmes to promote the upgrading of housing. In addition, we propose that the Horizontal Property Law (Ley de Propiedad Horizontal) be reviewed in order to give the community of owners a legal form enabling them to access the private financing available in the market. Legislative measures established by the Autonomous Communities within the scope of their responsibilities in relation to housing and other matters will also be relevant.

Public support programmes: programmes of aid through grants and financing for the energy upgrade of existing residential buildings, improving the energy rating. The programmes will prioritise actions that affect a high number of buildings: actions of urban regeneration and upgrading that affect areas identified as priority areas (districts) within the framework of housing policy.

These public funding programmes will include programmes ('Renovation Plans') aimed at actions or interventions that do not affect the entire building, only the individual homes of private owners to upgrade the sealing of gaps (windows and woodwork), roofs and facades independently, boilers and heaters, etc.

In any case, the public funding will be linked to compliance with social criteria, obtaining high levels in energy ratings, or improvements by 2 or more letters, and the application of general actions to simultaneously improve the thermal envelope and the thermal facilities of buildings.

Training: the training of the agents involved in the energy upgrade process (planners, project managers and agents responsible for external monitoring of energy standards) is essential for the successful implementation of public funding programmes. In addition, training on energy efficiency should be strengthened in the financial institutions that are key agents in driving new investments.

Information: Guides and manuals on aspects related to the energy upgrade will be developed and updated. Also, observatories, forums and round tables will be strengthened and a web platform will be maintained, aimed at companies and agents in the sector, which includes good practices in terms of energy upgrade.

Communication: specific information and communication campaigns will be conducted, which may include campaigns aimed at the creation of local or regional upgrade offices.

g) Specific measures or individual actions on energy poverty

The actions taken for households in a situation of energy poverty will receive greater concentrations of aid.

h) Financial requirements and public funding

The total estimated public funding to develop this measure in the 2021-2030 period is **€5509 million which, to a large extent, will come from European structural and investment funds corresponding to the new financial framework, that will enable** an investment volume of **€22 431 million to be raised throughout the period**.

Measure 2.7. Measures for the renewal of residential equipment

a) Description

The objective of this measure is to reduce energy consumption through the improved energy efficiency of household appliances, or more generically, household devices that consume energy.

Given that a significant number of domestic power-driven devices and household appliances in particular are renewed at the end of their life span, this is considered to be a good time to encourage buyers to replace them with appliances with a higher energy efficiency rating, from among those available on the market.

The new and additional savings derived from this measure (additional to those that will be obtained from application of the Eco-design Directives) will be those associated with bringing forward the decision to upgrade equipment (in relation to the time when it would have been replaced, following natural replacement levels), and the fact that the measure will stimulate the purchase of equipment with above-average energy performance of those on the market in each year of the implementation period of this Plan.

The priority will be devices whose energy consumption makes up a large part of consumption in the home, such as fridges, fridge-freezers and freezers, washing machines, dishwashers, ovens and cookers.

With a national estimated quantity of 76 million appliances (fridges, freezers, washing machines, dishwashers and televisions), the measure aims to achieve saving as a consequence of improving the energy ratings (with reference to the energy label) with regard to the benchmark category in the market at the time the replacement is made.

Considering that 6.6 million new white goods are sold each year, the target proposed implies the market penetration of 2 443 000 devices/year of the highest category of energy efficiency.

b) Expected cumulative and annual energy savings for each measure and/or quantity of energy savings in relation to any intermediate period

The target for this measure is to achieve **1 976 ktoe of cumulative final energy savings** during the 2021 - 2030 period.

c) Responsible Bodies

The public authorities responsible for the execution and follow-up of the measure will be MITECO/IDAE, together with the Autonomous Communities, following a model of joint management and joint financing of the measures and actions for energy efficiency that respects the distribution of competences in Spain.

The Public Administrations will collaborate to implement this measure among consumers and users, who must always play an active role by signing up to voluntary agreements.

d) Target sectors

This measure is aimed at the domestic sector.

e) Eligible actions

The actions proposed in this Plan are mainly communication actions to promote the awareness and use of more efficient household appliances, awareness of energy ratings and their importance as a decisive factor in the responsible and efficient purchase and use of household equipment. These communication actions will form part of a general strategy that will be of a permanent nature, aimed at citizens as the principal actors.

f) Mechanisms

The mechanisms for action that will enable the planned energy-saving targets to be achieved are as follows:

<u>Voluntary agreements</u>: voluntary agreements signed with associations of manufacturers, distributors and retailers of household appliances, in order to coordinate information and communication campaigns and actions in relation to consumers, as well as the training of sales staff.

<u>Training</u>: training activities will be designed and implemented in relation to this measure, which as a guideline may include, but are not limited to, training courses on energy efficiency for household appliances, aimed both at sellers of household appliances and citizens, organised in collaboration with associations of manufacturers, retailers and consumers, both on site and virtually.

<u>Information</u>: up-to-date information will be provided on energy ratings on the IDAE website, to promote information for the end users of the more energy-efficient appliances and systems.

<u>Communication</u>: we propose the implementation of a specific aid line for actions that contribute to promoting the **purchase of more efficient household appliances**, particularly highlighting energy savings and environmental commitment in the related communications. It should be consistent with the general communication strategy for the Plan, based fundamentally on information, training and segmented dissemination through the digital ecosystem (own and others' social networks, blogs, expert and sectoral forums) with advertising support that is also segmented. This line of communication will be developed continuously over time, intensifying to coincide with peak purchasing periods, in coordination with associations of manufacturers, distributors and retailers, supporting them from IDAE to activate their own communication initiatives.

In addition to communication on the purchase of household appliances with the highest energy efficiency standards, communication actions will be taken focusing on the **efficient and responsible use of appliances.**

g) Financial requirements and public funding

The public financial support will be used for communication campaigns.

Services sector

Measure 2.8. Energy efficiency in service sector buildings

a) Description

This measures aims to reduce the energy consumption in existing buildings used for services, owned publicly or privately, through energy upgrade activities that will improve their energy rating. As stated in Measure 2.6 of this Plan, about improving the energy efficiency of existing buildings in the residential sector, the certification of energy efficiency (Royal Decree 253/2013 of 5 April 2013) is a very useful tool for the promoters of upgrade activities when making new investments in existing buildings.

The measure includes two different sub-measures:

1) Extending the obligation of the National State Administration to upgrade public buildings (included in Article 5 of Directive 2012/27/EU) to Autonomous Community and Local Administrations.
2) The energy upgrading of buildings through public funding programmes and financing similar to the Aid programme for the energy upgrade of existing buildings (PAREER) in force since October 2013.

The first refers to the extension of the mandate contained in Article 5 of Directive 2012/27/EU **to all of the Autonomous Community and Local Administrations**, ensuring fulfilment of the proactive and responsible role of the public sector, which translates into a saving in the energy bill of the Public Administrations.

The second refers to the continuation of public funding programmes and financing for the energy upgrade of buildings in the services sector (similar to the PAREER programme).

b) Expected cumulative and annual energy savings for each measure and/or quantity of energy savings in relation to any intermediate period

The target for this measure is to achieve **1378.8 ktoe of cumulative final energy savings** during the 2021 - 2030 period.

c) Responsible Bodies

The public authorities responsible for the execution and follow-up of the measure will be MITECO/IDAE, together with the Autonomous Communities and Local Administrations, following a model of joint management and joint financing of the measures and actions for energy efficiency that respects the distribution of the relevant responsibilities in Spain.

d) Target sectors

This measures is aimed at existing buildings used for services, with public ownership by any Administration, or with private ownership. The beneficiaries of the aid programmes will be the owners or holders of existing buildings, whether they are legal or natural persons. In the event that the beneficiaries of the aid are legal persons of a private nature, the programmes will be adjusted to the regulations on state aid.

e) Eligible actions

Eligible actions for building upgrades will be those which achieve a reduction in CO_2 emissions and final energy consumption, by improving the services that take a greater share in the energy consumption of buildings, such as heating, cooling and the production of domestic hot water:

- **Thermal envelope**: action will be taken on the thermal envelope of buildings to achieve a reduction in demand for the heating and cooling of buildings. The energy efficiency actions may be applied to facades, roofs, floors, external woodwork, windows, solar protection, etc.
- **Thermal facilities**: action will be taken on the thermal facilities for heating, air-conditioning, production of domestic hot water and ventilation, which are governed by the Regulation on

Thermal Facilities for Buildings. The measure seeks to include renewable energy sources in meeting demand, in accordance with the targets for final renewable energy consumption considered in this Plan.

- **Lighting facilities**: action will be taken on the indoor lighting facilities of buildings, adapting them to the energy efficiency values required depending on how each zone is to be used; implementing lighting regulation and control systems based on the activity in each zone of the building and adapting lighting levels depending on the sunlight available.

f) Mechanisms

The mechanisms for action that will enable the planned energy-saving targets to be achieved are as follows:

Legislative measures: extension of the mandate arising from Article 5 of Directive 2012/27/EU for all Public Administrations.

Public funding programmes: aid schemes through grants and financing for the energy upgrade of service sector buildings, improving energy ratings.

Training: training for agents involved in the energy upgrade process (planners, project managers and agents responsible for external monitoring of energy standards, as well as those in charge of designing and managing energy facilities in public buildings) is essential for the successful implementation of public funding programmes. In addition, training on energy efficiency should be strengthened in the financial institutions, which are key agents in driving new investments.

Information: Guides and manuals on aspects related to the energy upgrade will be developed and updated. Observatories, forums and round tables will be also strengthened and a web platform will be maintained on the IDAE website for companies and agents in the sector, with databases and best practice in upgrading energy systems.

Communication: specific information and communication campaigns will be conducted.

g) Financial requirements and public funding

The total estimated public funding to develop this measure in the 2021-2030 period is **EUR 2.166 billion** which, to a large extent, will come from European structural and investment funds corresponding to the new financial framework, that will **raise investment of approximately EUR 3.671 billion.**

Measure 2.9. Energy efficiency measures for cooling equipment and large air-conditioning facilities in the services sector and public infrastructure

a) Description

The objective of this measure is to reduce electricity consumption in the services sector, and it can be divided into two:

1) measures to upgrade large air-conditioning facilities, cooling equipment and refrigeration and freezing compartments;
2) measures to improve the energy efficiency of publicly owned infrastructure, mainly street lighting systems and water treatment, purification and desalination facilities.

The first aims to reduce consumption in cooling facilities for the storage and conservation of perishable products in refrigerated warehouses and logistics facilities supplying urban areas, large air-conditioning facilities for service sector buildings (airports, hospitals, shopping centres, offices, etc.) and in small installations, units and deep-freeze boxes used in grocery stores, shops and retail areas.

The second aims to make Spanish street lighting compliant with Royal Decree 1890/2008 of 14 November 2008, approving the Energy Efficiency Regulation for street lighting, by regulating maximum lighting levels based on the activities carried out in particular areas and the impact of lighting on other areas, as well as increasing the minimum energy efficiency of light sources.

In addition, it aims to improve the energy efficiency of facilities for the treatment, supply and purification of water, by reforming existing facilities and introducing criteria for energy efficiency and low energy consumption in the specifications of calls for tender related to purification projects.

b) Expected cumulative and annual energy savings for each measure and/or quantity of energy savings in relation to any intermediate period

The measure aims to achieve **3 350.4 ktoe of cumulative final energy savings** during the 2021 - 2030 period.

c) Responsible Bodies

The public authorities responsible for the execution and follow-up of the measure will be MITECO/IDAE, together with the Autonomous Communities and local authorities, where applicable, following a model of joint management and joint financing of the measures and actions for energy efficiency that respects the distribution of competences in Spain.

d) Target sectors

The measure is aimed at the services sector, either natural or legal persons owning large refrigeration (more than 70 kWe) or air-conditioning facilities and the owners of small facilities, via units and chests, in grocery stores, shops and retail areas. In relation to public infrastructure, the measure is aimed at the local authorities and concession holders for the management of municipal public services.

e) Eligible actions

Eligible actions are those which achieve a reduction in CO_2 emissions and final energy consumption, by improving energy efficiency via:

- **Sub-measure 1.** Cooling equipment.

  Cooling equipment that improves energy efficiency through the incorporation of monitoring and control systems, the recovery of condensation and/or evaporation heat, and other equipment with high energy-saving capacity (multi-layer or capacity for variation of the condensation and/or evaporation temperatures). In the case of refrigeration units, the installation of covers or doors and replacement of lighting systems by new systems with lower energy consumption and heat dissipation.

- **Sub-measure 2.** Public lighting and water infrastructure.

  Replacement of bulbs by more energy efficient ones, improving the reflective and directional quality of the light and installation of systems to regulate the light flow of light sources and switching on and off, enabling variation throughout the night based on citizens' needs.

  In the case of facilities for the treatment, purification and desalination of water, improving efficiency by reforming the facilities for pumping and treating water, and generally, applying any upgrade that will mean a reduction in energy consumption.

f) Mechanisms

The mechanisms for action that will enable the planned energy-saving targets to be achieved are as follows:

Public support programmes: programmes of aid through grants and financing for this type of equipment and infrastructure. In the case of actions on publicly owned infrastructure, these programmes will have the additional technical assistance necessary for defining the technical specifications and public procurement.

g) Specific measures or individual actions on energy poverty

Actions which the local authorities are responsible for executing can be prioritised in accordance with the objectives of the regional policy for compensating for imbalances in regional income and ensuring balanced development consistent with a just transition.

h) Financial requirements and public funding

The total estimated public budget required to develop this measure in the 2021-2030 period is **EUR 3.947 billion** for a volume of **investment raised of EUR 6.333 million** throughout the period.

Agriculture and fishing sector

Measure 2.10. Improvement of energy efficiency in farms, irrigation communities and agricultural machinery

a) Description

The measure aims to reduce the consumption of energy in farms, irrigation communities and agricultural machinery through modernisation of existing facilities and upgrading of machinery and/or replacement of tractors and seeding machines. The measures will be implemented in synergy with those aimed at the promotion of renewables in this sector.

In this last case, giving continuity to the PIMA TIERRA Plan, launched in 2014, which has enabled improvement in the energy ratings of tractors and agricultural machinery (following the methodology developed by the Agricultural Mechanics Section and the IDAE).

b) Expected cumulative and annual energy savings for each measure and/or quantity of energy savings in relation to any intermediate period

The target for this measure is to achieve **1203.9 ktoe of cumulative final energy savings** during the 2021 - 2030 period.

c) Responsible Bodies

The public authorities responsible for the execution and follow-up of the measure will be MITECO/IDAE, together with the Autonomous Communities, following a model of joint management and joint financing of the measures and actions for energy efficiency that respects the distribution of competences in Spain.

d) Target sectors

This measure is aimed at the owners of farms and the owners or holders of tractors or agricultural machinery.

e) Eligible actions

Networks for capturing, storing, transporting, distributing and applying irrigation water will be eligible, as well as energy-consuming facilities in agricultural buildings and agricultural machinery.

f) Mechanisms

The mechanisms for action that will enable the planned energy-saving targets to be achieved are as follows:

Public support programmes: programmes of aid through grants and financing aimed at farms and owners of agricultural machinery.

Information: the development of guides and training workshops mainly aimed at irrigation communities.

g) Financial requirements and public funding

The total estimated public funding to develop this measure in the 2021-2030 period is **EUR 929 million,** which will **raise more than EUR 3.896 billion of total investment.**

3.2.2 Horizontal measures in relation to energy efficiency

3.2.2.1 Promotion of energy services

The role of energy providers was incorporated into the Spanish legal order by means of Royal Decree-Law 6/2010 of 9 April 2010, on measures to promote economic recovery and employment. Since then, Spain has approved plans and programmes with the main objective of promoting the procurement of energy providers by the public sector, as part of the duty of proactive responsibility towards the common good corresponding to it, driving new forms of procurement that support the achievement of energy savings and environmental improvements.

The recent publication of the Eurostat guide on accounting for Energy Performance Contracts (EPCs) has enabled the elimination of one of the main barriers making it difficult for Public Administrations to invest in the energy upgrade of their buildings (among other possible improvements in energy efficiency) in a scenario characterised by the need to maintain control of the public deficit.

This INECP considers energy service providers to be part of the new business fabric required to achieve the energy efficiency targets proposed for 2030. Following this principle, the different Regional Administrations, through the energy agencies - either IDAE, at national level, or others at Autonomous Community or local level - will provide new contract templates adapted to the recommendations of Eurostat and compliant with the new Public Sector Contracts Law.

Within the private sector, the procurement of energy services with different contract templates is a reality that will be strengthened in the time frame of this Plan by the removal of regulatory and administrative barriers to self-consumption. The new regulations on self-consumption will enable the roles of proactive energy consumer and aggregator, and finally new business models based on the generation of energy from renewable sources and the reduction of demand.

IDAE will resume its role as investor - directly or indirectly - in projects for energy efficiency and saving and renewable energies under the formula of recovery of investment through shared energy savings, as a means of highlighting the viability and profitability of energy efficiency and energy saving projects in the private sector.

3.2.2.2 Public sector: proactive responsibility and energy-efficient public procurement

<u>Proactive responsibility</u>

All of the Regional Administrations must take proactive responsibility for the promotion of energy efficiency and the increased use of renewable energies, leading the process of energy transition to a decarbonised economy by 2050.

In this INECP, this role is specified in the upgrade of 300 000 m^2/year in the General State Administration, above the 3 % required by the Energy Efficiency Directive. In addition, compliance with the target of improving energy efficiency by 32.5 % by 2030 requires **the adoption by the remaining Regional Administrations of at least the mandatory objective for the General State Administration, of upgrading 3 % of the built and air-conditioned surface area of the public building stock.**

In this respect, this National Plan considers an upgrade of **3 390 000 m²/year** of public buildings of the Autonomous Communities and local authorities to be achievable. It will therefore be necessary to promote cooperation between the managers of public buildings at national level and at autonomous community level.[43]

Specifically for the building stock of the General State Administration, the following actions are proposed:

- The prior definition and scheduling of upgrade actions for the building stock of the National State Administration, including annual targets for each Ministerial Department, in a way that guarantees that the annual upgrade target of 3 % of the surface area is achieved[44]. These actions should be planned and financed with the European funds set out for up to 2023 in Thematic Objective 4 (Low Carbon Economy) of the Multi-regional Operational Programme of Spain.
- Maintaining the inventory of buildings of the National State Administration through the web platform known as the 'IT system for Energy Management of Buildings of the General State Administration' (Sistema Informático de Gestión Energética de Edificios de la Administración General del Estado, SIGEE-AGE) and strengthening of the network of energy managers and supervisors assigned to the organisations and buildings of the General State Administration.
- The launch of information and training activities aimed at the managers and supervisors of the buildings of the General State Administration through specialist publications, virtual platforms and social networks.
- Promotion of self-consumption and the use of renewable energies in public buildings and the procurement of energy service providers.

Energy-efficient public procurement

Spanish legislation has a regulatory framework that promotes the use of energy saving and efficiency criteria in the procurement processes for goods, services and buildings by the Public Administrations[45].

The Plan for ecological public procurement of the General State Administration, its autonomous bodies and the management entities of Social Security (2018-2025), approved on 7 December 2018, has recently been added; it is defined as an instrument for promoting and facilitating economic growth based on the establishment of a circular, low-carbon economy.

[43] The Autonomous Community and Local Administrations are pioneers in the procurement of energy providers and in the use of energy performance contracts and public-private partnerships to finance energy efficiency actions. All the Autonomous Communities are achieving or planning to achieve energy efficiency plans in their public buildings.

[44] From 2014 to 2017, 1 240 035 m² were renovated, which represents a 105 % achievement of the upgrade targets established in Article 5 of the Energy Efficiency Directive.

[45] Law 15/2014 of 16 September 2014, on rationalisation of the Public Sector and other administrative reform measures, which includes certain energy efficiency requirements in its thirteenth additional measure for the purchasing of goods, services and buildings for Public Administrations included in the State Public Sector, and Law 9/2017 of 8 November 2017 on Public Sector Contracts, which requires the creation of assessment criteria which include environmental, social and innovation criteria aligned with the European policy on green public purchasing.

3.2.2.3 Energy audits and management systems

Spain has transposed the Energy Efficiency Directive through Law 18/2014, referred to previously with regard to Article 7 of the Directive, and Royal Decree 56/2016 of 12 February 2016, which transposes the Directive with regard to energy audits, accreditation of energy providers and energy auditors, and promoting efficiency in the supply of energy. Royal Decree 56/2016 imposes an obligation on large companies to conduct energy audits every four years, or as an equivalent to said obligation, the implementation of a system of energy or environmental management.

The audits must be conducted by duly qualified energy auditors (Article 4 of Royal Decree 56/2016). The Autonomous Communities and the towns of Ceuta and Melilla are the relevant authorities for the establishment and application of independent systems for inspecting the companies under obligation; the inspection should be conducted on a random selection of at least a statistically significant proportion of the energy audits conducted in each four-year period. In order to facilitate the conduct of the inspection, the Administrative Register of Energy Audits has been created, which is public and free of charge. It had received information on 35 000 energy audits by 3.12.2018.

The programmes of public aid and support for financing defined in section 3.2.1 of this Plan with a sectoral focus will use the mandatory energy audits as the principal diagnostic tool to define the eligible investment required to achieve the savings, and promote energy audits in small to medium-sized enterprises that are not subject to mandatory audits arising from application of the Directive.

3.2.2.4 Communication, information and training

The communication, information and training measures included in this INECP must address the requirements established in Articles 12 and 17 of the Energy Efficiency Directive, as well as leading to the necessary transformation of energy consumption habits required by the process of transition to a decarbonised economy by 2050.

The main vector of the communication strategy of this Plan is the fight against climate change and the close link between energy consumption and polluting emissions, with special emphasis on local pollution and transforming the models of towns and cities. Insofar as this Plan is based on the willingness to design a just transition to a new energy model, the communication strategy should provide information and training in a way that is easy to access by the most vulnerable consumers, to enable them to participate in the necessary social transformation and reduce energy poverty.

Specifically and as part of the previous general communication strategy, this Plan proposes actions aimed at financial institutions as the agents needed to raise approximately **EUR 86.476 billion of additional investment in energy efficiency**, that should enable the 32.5 % improvement in energy efficiency established as the target for 2030. These actions should improve the awareness of the financial agents and provide training to reduce the perception of investment risk for energy efficiency and saving which often penalises the promoters of this type of project and limits their access to finance.

IDAE will have a central role in defining and applying the communication strategy of the Plan. IDAE has regularly developed institutional communication campaigns that have enabled the accreditation of energy savings within the framework of Article 7 of the Energy Efficiency Directive, and it has developed audio-visual projects, publications and training platforms aimed at consumers in different sectors. IDAE also has experience with the creation and management of social network profiles in relation to energy efficiency.

3.2.2.5 Other measures to promote energy efficiency: the transition to highly efficient co-generation

Based on the statistics of the National Commission on Markets and Competition (CNMC) for sales of electrical energy within the special rules, the co-generated installed capacity (category A in the current Royal Decree 413/2014) in Spain at the end of 2017 was 5 705 MW. Co-generation has a strong presence in the industrial sector, where approximately 92 % of the installed capacity is located, the remaining 8 % being found in the service and residential sectors. The fuel mainly consumed by co-generation plants is natural gas, which represents 84 % of electricity production and 86 % of heat production, although there are also facilities that consume other conventional fuels or renewables.

It is estimated that by 2030, 2 400 MW of co-generated capacity will have exceeded its regulatory life span, and the priority financial rules will no longer apply. The age of existing facilities, as well as the necessity, in some cases, of redesigning them to adapt to new circumstances in the processes, means a potential loss of efficiency in terms of better outputs from the current turbines and engines.

On the other hand, the large-scale introduction of renewable power generation technologies established in the National Plan sets a challenge for co-generation as a support system that contributes to the stability of the system, and offers the flexibility that the operation of the electricity system will require in order to reach the established targets for energy generation from renewable sources.

In addition, the promotion of self-consumption encouraged by Royal Decree-Law 15/2018, with urgent measures for the energy transition and consumer protection, should drive the return to self-consumption of co-generation facilities connected to the network.

Based on this, a measure was proposed for the 2021-2030 period, aimed at the transition of co-generation to high efficiency **in a total of 1200 MW of co-generation facilities** using natural gas with an optimised design based on: useful heat, electrical self-consumption, flexibility of operation with regard to the electricity system and high efficiency, which would contribute to all the objectives set out in this Plan.

The mechanism set out is the competitive tendering procedure, with a multi-annual schedule of tenders, to determine a cost-effective remuneration scheme for the application of public funding, supported by the necessary administrative measures to take advantage of the existing infrastructure.

The need for facilities to be very highly efficient will be included in the application criteria for tenders, with design optimisation based on useful heat and electric self-consumption, and flexibility of operations with regard to the requirements of the System Operator. Inspection plans will be carried out that guarantee the effective use of the heat provided by co-generation in the process.

The estimated **savings associated with this measure are 1 471 ktoe of cumulative primary energy during the 2021-2030 period**.

3.2.3 Energy efficiency in gas and electricity infrastructure

Spain has introduced measures to remove tariff incentives that undermine the efficiency of the generation, transmission, distribution or supply of energy or that create obstacles to participation in the response to demand, to stable markets or to the procurement of ancillary services. Recently, it has eliminated barriers to self-consumption so that the energy system can begin the gradual transition to a model of distributed electricity generation, usually of low capacity.

Since Law 24/2013 of 26 December 2013 on the Electricity Sector was approved, and as a result of the approval of Royal Decree 216/2014, progress has been made on improving the participation of small consumers in the efficiency of the system and the response to demand. Royal Decree 1048/2013 has introduced incentives that contribute to reducing losses in networks; the first is intended to ensure continuous improvement in the level of losses in order to achieve an increase in remuneration without penalties, while the second is intended to reduce fraud.

This INECP accepts the conclusions and proposals of the evaluation reports on the energy efficiency potential of gas and electricity infrastructure approved by the National Commission on Markets and Competition in June 2016.

The measures considered to promote energy efficiency in the national electricity infrastructure include promoting design criteria based on efficiency, increasing line and cable sections, improving capacity factors and increasing voltage, upgrading substations, optimising the low-voltage network and the grid system, demand management, optimising the use of smart meters and reducing fraud.

Particularly for gas infrastructure, both for transmission and distribution networks and in regasification plants, a mechanism has been established to identify losses in the facilities, in order to incentivise the reduction of these by the owners.

3.2.4 Financial measures

The National Energy Efficiency Fund constitutes the main instrument to support national initiatives on energy efficiency during the application of the current INECP. This Fund, created by Article 72 of Law 18/2014, will be in force from 2020 until 31 December 2030.

Article 20 of the Energy Efficiency Directive enables member states to create a National Energy Efficiency Fund, and the revised Directive 2012/27/EU expressly recognises that the parties bound by the framework of the system of energy efficiency obligations set out in Article 7 can comply with the energy saving obligation through financial contributions to this Fund of a quantity equivalent to that of the investments required by compliance with the obligations arising from that Article.

The Fund can receive contributions from other sources, from the General State Budgets and principally from the European structural and investment funds (ERDF Funds) to promote a low-carbon economy. Returns on the ERDF funds can be expected for the 2014-2020 programming period (considering that Spain's Multi-regional Operational Programme had EUR 2.104 billion for a low-carbon economy and that the projects could be executed for the different investment priorities identified up to 2023) and the future programming period up to 2030. In addition, the National Energy Efficiency Fund will have resources derived from the return on the loans granted within the framework of call notices already implemented since 2015.

By aggregation, **this INECP will also raise approximately EUR 86 476 of additional investment in energy efficiency**, satisfying the principle of ‘energy efficiency first’ that should inform the policies to combat climate change, and therefore it will require approximately EUR 30 billion of public funds (national and European) in the form of direct public aid and public funding for the financing of energy efficiency projects. This Plan aims to activate and integrate the financial entities as the necessary agents to raise investment for energy efficiency and renewable energies, given that the energy transition should be conducted with the support of all the public and private agents and all the Regional Administrations, of all types.

3.3 DIMENSION ENERGY SECURITY

In accordance with the objectives set out in section 2.3 (National objectives and goals for energy security), the policies and measures that will be detailed in the following paragraphs will be coordinated through the present Plan, although we also note the framework to which they must be adjusted.

Thus, a considerable number of policies and measures fall within the scope of the Special Committee on Energy Security (created by Agreement of the National Security Council (Order PRA/30/2018 of 22 January 2018)). This Committee is a supporting body of the National Security Council, of those set out in Article 20.3 of Law 36/2015 of 28 September 2015 on National Security, which has the role of exercising the functions assigned by the National Security Council in terms of energy security and within the framework of the National Security System. Among other things, these functions include conducting a risk and threat assessment, analysing potential crisis scenarios, particularly those likely to arise from a situation of interest for National Security within the scope of energy security, and evaluating the results of their execution. This should all be carried out in coordination with the bodies and authorities with direct responsibility and with the Special Situations Committee.

It should be noted that, as a fundamental part of the National Security System, Objective 2 of the National Energy Security Strategy specifically establishes the need to 'consider all the energy sources to maintain a balanced mix, which accurately reflects all the specificities of Spain and enables it to reach a certain guarantee of supply, at competitive prices, and within a sustainable model in which clean energies steadily take on greater importance '.

Specifically, with regard to hydrocarbons, the reference standard is Royal Decree 1716/2004 of 23 July 2004, which regulates the obligation to maintain the existing minimum security requirements, the diversification of natural gas supply and the Corporation of Strategic Reserves of Petroleum Products (Corporación de Reservas Estratégicas de Productos Petrolíferos, CORES), which plays the role of 'Central Stockholding Entity'), in accordance with Council Directive 2009/119/EC.

On the other hand, all measures related to security of supply in the gas sector should comply with the provisions of the future Regulation concerning measures to safeguard security of gas supply, by which Regulation (EU) No 994/2010 of the European Parliament and of the Council is repealed. Similarly, they must comply with the System Technical Management Standard number 11 (NGTS-11), currently under review, which sets out the measures to be taken in the event of an emergency, in order to adapt it to the new EU regulation and improve coordination between the agents in the gas system. The approval of a new additional Detailed Protocol is expected, establishing the obligation to conduct emergency exercises, with scenarios approved by the Competent Authority and coordinated by the System Technical Manager, with no prior notification for the agents involved. To conduct these exercises, where interconnections exist, the Transmission System Operators (TSOs) of the Member States will be advised with the minimum notice, so that regional cooperation can also be subject to evaluation.

Starting with the development of measures, first, with regard to the intense reduction of energy dependency, especially with regard to the importing of fossil fuels, this will be sustained, uniquely, through two vectors. On the one hand, through the implementation of energy use efficiency measures (corresponding to section 3.2. of this Plan: Energy efficiency policies and measures). On the other hand, through the development of national renewable energy sources, with all the implications of this in terms of control over primary resources, for which Spain has a high potential, given our special geographic and climatic features, particularly for solar and wind power. The corresponding measures can therefore mostly be found in section 3.1. (Decarbonisation policies and measures).

This self-sufficiency of sources is boosted by the availability of national technology developed by a cutting-edge industry, which represents an international benchmark and is in a position to take advantage of the opportunity proposed by this Plan in economic terms and for generating employment. The measures considered in section 3.5 will therefore also contribute to this objective. (Policies and measures for research, innovation and competitiveness).

Furthermore, we must not forget the diversification of supply sources, ensuring the availability of a sufficiently wide range of geographical origins, so that geopolitical instability in producer countries or maritime transport routes does not have a significant impact on the national market.

Special attention should be paid to the energy dependency of non-mainland regions. In particular, the Canary Islands, with a current dependency on petroleum as a primary energy source of 98 % and with an isolated electricity system, will require a major effort of interconnection between the islands, and greater development of technologies to support decarbonisation (both of these aspects are included in other dimensions of this Plan). In this regard, the following measure has been formulated:

Measure 3.1. Reducing dependency on petroleum and carbon in the islands

Generally, and as expressed in the decarbonisation dimension, the design and implementation of sustainable energy strategies in the islands will be promoted. In addition, the contribution to the electrical mix of fossil fuel power stations located in the Canary Islands will be reduced by 50 % by 2030 compared to the current status, and therefore a specific plan will be prepared after the final approval of the INECP. In the case of the Balearic Islands, the existing coal-fired power station will close two of its four generator sets by 2020, leaving two remaining generator sets as a reserve until the effective integration of the Balearic electricity system into the mainland system.

With regard to enhancing the diversification of national energy sources, this will be carried out while monitoring technical progress, and includes the following main measures:

Measure 3.2. Alternative fuel recharging points

We will continue to promote the installation of alternative fuel recharging points.

In the preparation plan to address limitations or interruptions to energy source supply, the following measures will contribute to achieving the stated objectives:

Measure 3.3. Promoting regional cooperation

An increase in the physical electricity interconnections with neighbouring energy systems, which will contribute to reducing the possible impact of limitations or interruptions in the national supply of energy sources. In addition, we propose optimising the use of existing capacity by reducing barriers to energy exchange.

In this respect, we note that the regulatory authorities maintain continuous contact with their regional counterparts for the appropriate implementation of European regulations through the Agency for the Cooperation of Energy Regulators (ACER) and other working groups. On the other hand, the market operators work together to facilitate the integration of the markets as reflected, in the case of electricity, in Spain's participation in the continuous intra-day market. In addition, the system operators maintain regular contact at regional level to analyse and ensure the security of supply, implement European regulations and ensure the effective use of international interconnections through the European Network of Transmission System Operators for Electricity (ENTSO-E) and other working groups.

In addition, although this question is considered in greater detail in the Internal Energy Market dimension, we note that the increase in capacity of electricity interconnections with France significantly contributes to reducing the isolation of the Iberian peninsula, which has come to be known as an ‘energy island’, from the rest of Europe.

At internal level, the Spanish energy system is now in a very advanced position with regard to preparation for contingencies. In this respect, we note the role of Law 8/2011 of 28 April 2011, establishing measures for the protection of critical infrastructure, and the Development Regulation for this, based on European standards. However, it is necessary to extend this preparation, in the context of the different international domains to which Spain is committed: International Energy Agency (IEA) and various EU directives and regulations for the electricity and gas sector. Thus, the following measures include various planned actions:

Measure 3.4. Extension of contingency plans

The principal actions will include:

1) developing the National Security Strategy, through the recently created Special Committee on Energy Security;
2) adapting to the new European regulation on preparation for risks in the electricity sector;
3) improving the various preventive and emergency plans with regard to the supply of electricity, gas and petroleum derivatives.

In the electricity sector, the objective of these plans is to prevent the unfolding of incidents that may have significant repercussions on supply or generating units, minimise the scope and the scale of incidents when they occur, and return the electricity system to normal operating status after severe incidents that have caused power cuts. With this goal, a general and zonal security analysis will be conducted to evaluate the risk of supply failure that could arise from our own production resources, taking into account the availability of fuels, hydro-electric reserves in reservoirs and water availability, with several assumptions about both demand and availability of the generating units.

At European level, we note the recent approval of the Regulation establishing a network code for emergencies and restoration of supply[46], which gives details of a series of requirements to safeguard the security of supply, conditions to be met by the agents, listing of responsible persons and priority users, rules for suspension and restoration, settlements and testing plans. This Regulation, together with the proposal of the European Parliament for risk preparedness in the electricity sector, included in the European Commission package *Clean Energy for All Europeans*, will enable harmonisation of risk preparedness at European level and improvement in its general security.

In the petroleum products sector, the following actions are considered necessary:

- Updating the Contingency plan for crisis situations in the petroleum markets: confidential document, prepared by CORES and regularly updated according to the criteria established by the IEA, which have established four Action Phases, from major to minor severity with regard to potential difficulties of supply of crude oil and petroleum products.
- Updating the Plan for demand restriction measures in the event of a crisis in the petroleum market: confidential document, prepared in 2015 by the MERCOP group (Measures to Restrict the Consumption of Petroleum) specifically created for this purpose, including various ministerial departments and bodies of the General State Administration.
- Participating in emergency exercises regularly conducted by the European Commission and the International Energy Agency. Spain's participation in the simulated emergency situation ERE 9, conducted in 2018, can be cited as an example.

In addition, with the aim of reaching a certain level of energy security at regional level within the EU framework, we must establish objectives and measures for supply security of petroleum products at regional level, so that:

- The obligation to store 90 days' worth of consumption or 60 days' worth of imports of crude oil and petroleum products can be met at regional or EU level.
- Reviewing the proportionality of the level of obligation and the methodology to account for existing supplies, where both are adapted to the reality of the global oil market and the state of the art.
- Reviewing the form of compliance with the obligation, so that the methodology for accounting for existing stocks encourages them to be composed of finished products.
- Reviewing the form of compliance with the obligation, so that the methodology for accounting for existing stocks encourages them to be located near to consumption centres, taking deployment times into account.
- Establishing general standards for the process of accreditation of an operator's compliance with standards, through storage reserves located in other Member States.

While these general standards are introduced, Spain plans to approve a Ministerial Order to implement Article 11.2 of Royal Decree 1716/2004, in order to establish a unique procedure for authorising the storage of countable reserves for other Member States within national

[46] COMMISSION REGULATION (EU) 2017/2196 of 24 November 2017, establishing a network code on electricity emergency and restoration.

boundaries, avoiding the need for new bilateral agreements. However, various procedures for the bilateral agreements already signed (with France, Portugal, Italy, Ireland, Malta) will continue to exist and be necessary so that their national obligated undertakings meet their obligations through storage reserves in other Member States.

With regard to the gas sector, the Preventive Action Plan and Emergency Plan will be updated in application of Regulation (EU) 2017/1938 of the European Parliament and of the Council concerning measures to safeguard the security of gas supply, and also the Emergency Action Plan (PACE) in application of Article 40 of Royal Decree 1716/2004.

The following modifications are also set out in order to establish objectives and measures for natural gas supply security at regional level, such that:

- the infrastructure standard (N-1) of Article 5 of Regulation (EU) 2017/1938 must be complied with at regional level, taking the existing level of interconnection into account.
- the supply standard of Article 6 of Regulation (EU) 2017/1938 must be followed at regional level, taking into account the imposition of different national demands and the existence of different national measures taken to meet them;
- the Preventive Action and Emergency Plans will be developed at regional level.

To comply with the foregoing, regions must be established that are distinct from the risk groups created in Appendix I of the abovementioned regulation.

Finally, with regard to the energy flexibility plan, we note that a transformation of the Spanish energy system as thorough and ambitious as that presented in this Plan also brings a series of challenges that cannot only be addressed from the perspective of energy supply. In particular, the decisive commitment to renewable energies in the electricity generation sector entails a greater variety of generating profiles. This variety of supply can be compensated for by the development of various large-scale energy storage solutions, still on the supply side (hydraulic pumps or batteries), but also on the demand side through the promotion of different solutions to give the system flexibility. These actions are set out in 'Measure 1.2. Integration of renewables into the electricity grid'.

In the same area, technological advances have enabled the existence of a series of technological solutions still not fully explored in the electricity sector regulations, but they are required to play an important role in ensuring the continuity of electricity supplies, in particular all the optimisation that enables the intensive use of information and communication technologies in the energy system. Thus, also contributing to the dimension of the Internal Energy Market, we will adapt the regulations on:

1) Distributed generation and storage of electricity. This measure includes all the developments in relation to self-consumption.
2) Further progress in the elimination of barriers related to electric vehicles (such as the recent elimination of the role of charge managers).
3) Boosting forms of aggregated generation, response to demand (including interruptibility) and storage (virtual power plants*)*.
4) Participation of renewable technologies in more services of the electricity system: deviation management, regulation services, etc.

With regard to point 3 of the previous measure, we note that the real and gradual integration of the service of interruptibility demand management in the adjustment service markets results in the more frequent use of this service, and therefore in a reduction of electricity consumption at prices increasingly comparable to those observed today by the generating undertakings that participate in the adjustment services. Following this, the 'Statute of Intensive Electricity Consumers' was approved in Royal Decree-Law 20/2018 of 7 December 2018, with urgent measures to drive economic competitiveness in Spain's industry and commerce sector, which recognises the specificities of industrial electricity consumers with high use of electricity, high use at times of low electricity demand and a stable and predictable consumption curve.

This statute also meets economic criteria, acting on situations in which the application of the service implies a lower cost than the adjustment services of the system. Thus, for the application of the interruptibility service by economic criteria, it will be checked that the implementation of the capacity reduction option, taking all the associated settlement into account, will result in a reduction of the total cost of the energy to be managed at that time. In addition, certain measures have recently been adopted to make the criteria allowing implementation of the capacity reduction options more flexible when their settlement is less costly than the activation of other market mechanisms.

In relation to interruptibility in both markets (gas and electricity), in compliance with Regulation (EU) 2017/1938, we plan to establish and regularly update the list of critical electric power stations supplied by gas and their volumes of consumption, so that these volumes can be taken into account if another Member State requests the application of solidarity measures. With this goal, a working group will be created together with the electricity System Operator, the System Technical Manager and the Competent Authority in accordance with Regulation (EU) 2017/1938.

With regard to point 4, it should be noted that Spain is one of the pioneering countries for including renewable energies in the various adjustment services. Since February 2016, these facilities can participate in the adjustment service markets of the system, after passing the authorisation tests. From the start of 2018, almost half of wind power generation has been authorised for participation in deviation management services and tertiary regulation, which shows sufficient progress in the integration of renewables into these services. We must highlight the role played by the system operator in this context, whose control centre currently enables the observation and control of power generating stations of more than 1 MW and 10 MW, respectively.

In conclusion, and as already noted, it is important to emphasise that the dimension of energy security is closely related to the other dimensions of this Plan:

- the internal market dimension, with which it shares instruments such as electric and gas interconnections, or demand management;
- Research, Innovation and Competitiveness (RIC), as developments in batteries or Power-to-gas depend on the more economical implementation of these key technologies in the future of supply security;

- with regard to the decarbonisation dimension, the high use of renewables in the system creates challenges for managing them, as well as integrating them into transmission and distribution networks;
- and the energy efficiency dimension, since various solutions in this domain, such as local energy networks, also lead to system resiliency.

3.4 DIMENSION INTERNAL ENERGY MARKET

Firstly, with regard to the interconnectivity of the electricity system, we will continue to work on what was agreed in the Madrid Declaration - Summit for Energy Interconnections, held by Spain, France, Portugal, the European Commission and the European Investment Bank in Madrid on 4 March 2015, and ratified in June 2018 in the Lisbon Declaration. In the Madrid Declaration, a common strategy was adopted for the development of electricity transmission activities and a new high-level Regional Group for South-West Europe was created for the promotion and supervision of interconnection projects. This strategy was ratified in the Lisbon Declaration.

In this domain, the main measures are aimed at construction of the following essential interconnections:

Measure 4.1. Increased electricity interconnection with France

- Bay of Biscay Project: Interconnection between Aquitaine (FR) and the Basque Country (ES), which will enable the interconnection capacity between Spain and France to reach 5000 MW.
- Interconnection between Aragon (ES) and Atlantic Pyrenees (FR) and interconnection between Navarre (ES) and Landes (FR), which will increase the interconnection capacity between Spain and France to 8000 MW.

The most important of these projects, the Bay of Biscay project, was considered in the 2017 Projects of Common Interest (PCIs)[47] as an interconnection between Aquitaine (FR) and the Basque Country (ES). This is an interconnection between the Basque Country and Aquitaine that is 370 km in length (110 km in Spain and 260 km in France), of which 90 km are terrestrial and 280 km are undersea, with an estimated cost of EUR 1.75 billion. This project will allow the capacity of the interconnection between Spain and France to reach 5 000 MW (5 % of installed capacity).

The remaining ones are also included in the list of 2017 PCIs, with details given below:

- The interconnection between Aragon (ES) and Atlantic Pyrenees (FR) has 150 km planned on the Spanish side, at an estimated cost of EUR 1.2 billion.
- The interconnection between Navarre (ES) and Landes (FR) has 80 km planned on the Spanish side, at an estimated cost of EUR 1.2 billion.

The connection with Portugal is not so critical for the Spanish electricity system, as the process that led to the creation of the Iberian Electricity Market (MIBEL) involved close cooperation between the governments of Spain and Portugal. As a result, from the start in July 2007, MIBEL has been one of the most liquid markets in Europe, providing multiple benefits for the consumers of both countries, in a framework of participation open to all the interested parties under conditions of equality, transparency and objectivity. Even so, given that in 2017, 6.7 % of the hours were not matched in the daily market due to congestion in the interconnection with Portugal, the following measure is considered appropriate:

[47] COMISSION DELEGATED REGULATION (EU) 2018/540 of 23 November 2017 amending Regulation (EU) No 347/2013 of the European Parliament and of the Council as regards the Union list of projects of common interest

Measure 4.2. Increased electricity interconnection with Portugal

To increase the capacity for interchange between Spain and Portugal to 3 000 MW.

This new interconnection with Portugal, also included in the 2017 list of PCIs, is intended to increase the capacity for interchange between the two countries to 3 000 MW, at an estimated cost of EUR 128 million. The project comprises the following facilities on the Spanish side, located in the provinces of Ourense and Pontevedra:

- 400 kV DC power line, with input and output at Beariz on the Cartelle-Mesón do Vento line;
- Beariz 400 kV transmission substation;
- 400 kV DC power line, Beariz-Fontefria;
- Fontefria 400 kV transmission substation;
- 400 kV DC power line, Fontefria-Portuguese border.

In the financing of said electricity interconnections, as well as the remaining PCI infrastructure, the ‘Connecting Europe Facility’ (CEF) programme, created pursuant to Regulation EU 1316/2013 of the European Parliament and of the Council of 11 December 2013, will play an important role. This was developed to promote European infrastructure of special interest, through economic aid from the EU via competitive calls for proposals or financing applications presented by the bodies charged with the construction of this infrastructure, always with the approval of each member state.

Measure 4.3. Electricity transmission infrastructure other than the ‘Projects of Common Interest’ (PCIs)

- 400 kV Abanto/Güeñes - Ichaso axis.
- Actions in the metropolitan area of Barcelona.
- Pyrenean region. Moralets.
- Mequinenza axis interconnection.
- Axis of the 220 kV JM Oriol-Los Arenales-Cáceres-Trujillo network mesh.
- 220 kV Valencia capital network mesh.
- Strengthening of the 220 kV axis between La Plana and Morvedre.
- Strengthening of the 400 kV network between Castellón and Valencia.

It should be noted that the development of actions from the previous infrastructure list, which may affect neighbouring electricity systems, will be carried out in cooperation with the TSOs to minimise the potential effects and impacts on both electricity systems.

Measure 4.4. Integration of the electricity market

It will consist of the following initiatives:

1. Increasing the contribution of renewable energies to adjustment and balancing services. The necessary measures will be provided for storage development and demand management, also contributing to the energy security dimension.
2. If required, necessary measures will be adopted to promote the decarbonisation of the economy with the objective of ending the provision of energy from carbon-based power stations to the system by 2030.
3. The necessary measures will be taken to improve the capacity to manage hydroelectric power, in order to maximise the integration of renewable energies (this measure is supplemented by the increase in energy storage, within the energy security dimension).
4. Promoting participation of consumers in the electricity market. Development of Royal Decree-Law 15/2018 on self-consumption and renewable energy communities.

In relation to the final point of the previous measure, based on the great effort made by Spain in the deployment of smart meters launched in 2008 and completed at the end of 2018, consumers have a basic tool for understanding their hourly consumption, becoming active consumers, and adjusting to prices in the electricity market. Active consumers can adjust their demand at times when the market prices are lower, contributing to shifting the demand curve and thus facilitating a reduction in the prices of electrical energy.

In this regard, it is essential to continue making progress within an enabling framework which supports the promotion of self-consumption and renewable energy communities. In this regard, the provisions of Royal Decree-Law 15/2018 of 5 October 2018 on urgent measures for the energy transition and consumer protection will be developed, taking as a premise the search for the greatest simplicity possible in the technical and administrative requirements, so that they do not create a barrier to the development of self-consumption. Therefore the role of the charge managers has been removed, and recharging activity has been liberalised, so that any consumer can provide recharging services. In addition, the managers of ports, airports and rail infrastructure, in their role as consumers, can provide electricity supply services to vessels, aircraft and railways, and services inherent to the provision of that service, enabling vessels and aircraft to stop consuming fuel while they are located in these facilities. This will contribute to the objective of achieving low-emission transport.

For the specific aspect of electricity consumer protection and improving competitiveness in the retail sector, the following measure is proposed:

Measure 4.5. Electricity consumer protection and improving competitiveness

It will consist of the following initiatives:

1. Establishing a dynamic framework of standards which can be adapted to the constant development of the sector and which protects the most vulnerable consumers by promoting competitive and transparent prices. To do this, in the coming months, an analysis will be made of the necessary reforms in the design and operation of the electricity market. In addition, an analysis will be made of new designs of smart tariffs to promote electrification, demand

management and the rational use of infrastructure, and contribute to the objectives of decarbonisation.

2. Facilitating consumers' understanding of supply and the conditions of supply procurement, enabling them to make better decisions about electricity consumption, to achieve more efficient behaviour and a less harmful impact on the environment.
3. This will be extended with the promotion of free competition between electrical energy providers.

With regard to the Spanish gas market, its reinforcement and development is considered essential in the next decade, which requires the following initiatives:

Measure 4.6. Integration of the gas market

This will consist of the following initiatives:

1. Establishing the logistical model of regasification plants through the development of Royal Decree 984/2015, to maximise flexibility in the system, allowing progress towards a model that enables liquid natural gas (LNG) sales contracts, regardless of the physical plant in question.
2. Expansion of the measures for promoting liquidity (mandatory negotiation in the organised market of natural gas for certain purposes, market creators).
3. Taking advantage of the storage capacity for LNG in Spanish plants, as well as their capacity for regasification, to convert them into a physical hub at EU level, both for natural gas and renewable gas or hydrogen.

These measures have been developed within the framework of Law 8/2015 of 21 May 2015, which created the organised market for gas (MIBGAS) and appointed the market operators, with the objective of filling the gap for an organised secondary wholesale market which will provide a transparent price signal and boost competition in the sector.

As for the electricity market, the entrance of new providers is also proposed for gas, as well as a reduction in the administrative burden for providers of natural gas in their relations with the Administration.

With regard to consumer protection, responding to the general objective of providing them with the information they need to make decisions on the consumption of natural gas with total independence, the following measures are proposed so that they can be informed at all times of the volumes of gas consumed and its environmental footprint (emissions, proportion of renewable gas consumed, real-time consumption, online billing consultation, etc.).

Measure 4.7. Protection of gas consumers

It will consist of the following initiatives:

1. Simplifying link-ups: introducing the possibility of execution by the applicants themselves, through modification of Article 25 of Royal Decree 1434/2002.
2. Simplifying the process of changing provider: introducing a process that prevents delays and extending the powers of review of the regulator, through the amendment of Articles 41 and 42 of Royal Decree 1434/2002.

3. Reducing fraud: strengthening the role of distributors in the detection of fraud and communication procedures with providers, through the amendment of Articles 61 and 62 of Royal Decree 1434/2002.
4. Implementing smart meters: technical and financial analysis of the potential implementation of smart meters for consumers, supplied at a pressure equal to or lower than 4 bar, based on the report to be prepared by the National Commission on Markets and Competition in compliance with additional provision four of Order ETU/1283/2017 of 22 December 2017.

Measure 4.8. Improving the competitiveness of the retail gas sector

It will consist of the following initiatives:

1. Imposing new obligations on the dominant operators in the natural gas sector, based on their retail market quota.
2. Creating a single central point of statistical reporting in the Administration for providers, based in the State Secretariat for Energy, which in turn will provide the information required by other bodies (CNMC, CORES).
3. Simplifying the electronic procedure for setting up new providers.

In this regard, we note the effect of measures such as those contained in Royal Decree Law 15/2018, consisting of the introduction of an extension in the Special Tax on Hydrocarbons for energy products used in the production of electricity in electric power stations or in the co-generation of electricity and heat in combined power stations.

Measure 4.9. Development plan for gas demand management

Geographical areas will be selected where preventing the potential interruption of supply to unprotected clients could be essential to safeguard energy security.

In addition, this plan must pre-select unprotected clients with a sufficient volume of consumption and economic activity to support these mechanisms.

As a consequence of the previous development plan, the national regulation to provide these approved mechanisms must be developed within the established time frame. In particular, the main tools include the following:

- Interruptible tariff: possibility of interruption of supply to clients subject to this type of transmission and distribution tariff, for a lower amount than the fixed tariff, with the option of reducing the demand to be satisfied by the system in the event of lack of supply or saturation of gas pipelines in extreme conditions.
- Demand management systems: the development of demand management systems is planned, allowing unprotected consumers to relinquish volumes of contracted gas,

putting them on the market at a fixed price through competitive procedures, in accordance with Regulation (EU) 2017/1938.

Measure 4.10. Combating energy poverty

a) Description

The reports of the Association for Environmental Sciences (ACA) describe energy poverty as a situation in which a household 'is incapable of paying for sufficient energy to meet its domestic needs and/or when it is obliged to use an excessive share of its income to pay the energy bills for its home'. Currently, a very high number of Spanish households find themselves in a situation that falls within the stated ACA definition, which has brought the concept of 'energy poverty', with its specificities and complexity, to the centre of the debate on poverty and inequality in Spain.

In relation to the INECP, the treatment of energy poverty will be addressed in an integrated way, in its five dimensions, and in particular with regard to decarbonisation and energy efficiency measures, guaranteeing access to energy supplies to all vulnerable persons, in a way that satisfies their basic needs, with particular attention paid to certain groups which are the most vulnerable due to their special characteristics.

Energy poverty will be addressed from an integrated perspective, based on indicators that facilitate the orientation of the measures and pursue maximum efficiency, evaluating the possible routes for financing and strengthening the monitoring and supervision of its implementation. The main instrument will be the approval of the National Strategy to Combat Energy Poverty, which will bring together the various social benefits: thermal (fuels for heating, domestic hot water and cooking) and electric, within the framework of the Just Transition Strategy.

In this respect, we note that Article 1 of Royal Decree-Law 15/2018 commits to the development of the aforementioned National Strategy to Combat Energy Poverty within the time period of six months from its entry into force (i.e. 7 April 2019); to that end, work will start with a diagnosis and description of the problem in Spain. Within the framework of this strategy, official indicators will be designed, targets to reduce energy poverty will be approved for the medium and long term, and regulatory and non-regulatory measures will be designed, as well as measures for cooperation with Public Administrations and social agents, and communication. In addition, the corresponding financing mechanisms will be developed, as well as mechanisms for evaluating and reviewing the results.

b) Objectives addressed

Developing the mandate of Article 1 of Royal Decree-Law 15/2018, to develop a national strategy to combat energy poverty within 6 months from its entry into force (7 April 2019).

c) Mechanisms

For the preparation of the National Strategy against Energy Poverty, the following is proposed:

- **Diagnostic and description of the problem.**

  A definition of energy poverty and vulnerable consumers will be articulated in consultation with the final regulation established by the Electricity Directive and the Governance Regulation.

  Subsequently, the corresponding statistical instruments will be used, together with the consultation and participation of public bodies and private actors to obtain a representation of the situation in Spain.

- **Design of official measurement indicators.**

  These can be used to conduct an analysis prior to the Strategy, to establish the needs and areas of action that it should cover. The development of these indicators will be subject to continuous analysis and will serve as a basis for establishing the necessary objectives.

- **Establishing objectives to reduce energy poverty in the medium and long term.**
- **Design of measures to achieve the objectives.**

- **Design of financing mechanisms.**

d) Responsible Bodies

The General State Administration (MITECO), Ministry of Economy and Enterprise (MINECO), National Institute of Social Security, Autonomous Community and Local Administrations, sectoral associations.

3.5 DIMENSION OF RESEARCH, INNOVATION AND COMPETITIVENESS

The future Spanish Science and Technology Strategy for the 2021-2027 period will consider the possibility of incorporating a Strategic Action on Energy and Climate Change, as well as in its development plans; and assigning a quantity of finance for Research, Innovation and Competitiveness (RIC) in energy and climate. This point signifies a change with regard to the current structure of state planning of Research, Development and Innovation (RDI), as currently all calls for financing are evaluated and determined strictly based on criteria of excellence, without defining the levels of finance for sectors or specific challenges.

3.5.1 Policies and measures to achieve the national objectives

To ensure coverage of the firmest commitments of the Government with regard to science, technology and innovation, such as energy and climate, and **given the non-specific nature of the current RDI planning, the instruments of those financing the Spanish system of science and technology can be used for actions on energy and climate.**

Without prejudice to the above, below is a detailed list of some of the most relevant measures.

Measure 5. 1. Strategic action on energy and climate

a) Description

The aim is to cover a firm commitment of the Government with regard to science and technology through the identification of a strategic action. Thus, each strategic action includes integrated management of all the necessary actions.

To ensure coordination of the activities and the achievement of the established objectives, this strategic commitment will define specific objectives, and will establish a specific budgetary commitment applicable throughout the period of the future State Strategy on Science, Technology and Innovation and the Plans developed for it.

b) Objectives

- Developing a common strategy that avoids duplication and ensures continuity of the priority lines of research and the communication of results to the Public Administrations.
- Improving the transfer of knowledge and scientific excellence.
- Promoting innovation in the private sector.
- Increasing the returns of European programmes on energy and climate change.

c) Mechanisms

- State Strategy on Science, Technology and Innovation 2021-2027.
- State Plan on Scientific and Technical Research and Innovation 2021-2024.

d) Responsible Body

The Ministry of Science, Innovation and Universities, in coordination with MITECO.

This measure is also aligned with the strategies for smart specialisation to improve knowledge exchange between political agents and the interested parties, above all supporting the participation of SMEs.

Measure 5.2. Implementation of the SET-Plan

a) Description

The mission of the SET PLAN (European Strategic Energy Technology Plan) consists of accelerating the development and deployment of low-carbon technologies[48]. Within the framework of the SET-Plan, the Ministry of Science, Innovation and Universities, in coordination with the Ministry for Ecological Transition, and in close coordination with CIEMAT and CDTI, works in groups that address RIC needs in: solar photovoltaic energy, concentrated solar power, wind power, geothermal power, ocean technologies, carbon capture, storage and use, bioenergy and biofuels, batteries, new materials and technologies for energy efficiency in buildings, energy efficiency in industry, smart energy systems, smart and sustainable cities, etc.

To implement the 10 priority actions identified in the SET-Plan, 14 Temporary Working Groups (TWGs) will be established with the mission of developing an implementation plan[49] for each of the technologies represented in each group. Spain participated in all the TWGs and led the one on Concentrated Solar Power (CSP).

Once the implementation plans were adopted, the TWGs were gradually replaced by the formation of Implementation Working Groups (IWGs). As with the Concentrated Solar Power TWG, Spain led the CSP Implementation Group.

b) Objectives

The SET-Plan was developed based on the 5th pillar of the Energy Union, with the following priorities:

- Europe must be a global leader in the development of the next generation of renewable energies;
- We must facilitate the participation of consumers in the energy transition;
- Efficient energy systems will be established;
- More sustainable transport systems will be promoted.

c) Mechanisms

From now, the main task is to facilitate the launch of the actions identified in the SET-Plan Implementation Plans.

d) Managers

The Ministry of Science, Innovation and Universities, in coordination with MITECO, through its Strategy and RDI plans, financial agents and research centres. The participation of industry is also important.

Measure 5.3. Programme for the development of the "Cervera" Network of Technology Centres and Institutes of Excellence (example instrument of the Centre for Industrial Technology Development, CDTI)

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[48] To do this, the necessary actions and strategic priorities have been identified to accelerate the transformation of the energy system in an effective way, identifying duplication and synergies at European and national level, coordinating national and European efforts in research and project financing. We understand the SET-Plan as a roadmap for coordinated research to develop a portfolio of technologies that are low in carbon emissions, clean, efficient, affordable and with large-scale market penetration.

[49] The Implementation Plans include the specific RIC actions needed to reach the stated objectives, and the financing and mechanisms needed for their implementation. This process is led by the countries participating in the SET-Plan, in close collaboration with the EC and with a very active role by research centres and industry.[50]These figures do not include the specific investments in thermal renewables in the industrial sector and agricultural sector. Investments in rail transport have not been considered either.

a) Description

The Cervera network constitutes a new ordering of priorities when assigning resources and currently existing processes, prioritising private projects that involve the contracting of technology centres or other accountable (non-profit) public-private bodies.

b) Objectives addressed

The objective is that all the knowledge generated in the research bodies translates into an increase in GDP, due to the marketing and internationalisation of new products or innovative processes created due to the generated technology transfer. This measure therefore aims to boost research and innovation, applied through collaboration between Technology Centres and SMEs on priority technologies. Various thematic areas have been defined that group the priority technologies, in relation to advanced materials, eco-innovation, energy transition, smart manufacturing, advanced mobile networks, or smart transport.

c) Measures

Cervera Transfer Research and Innovation (R&I) Projects

d) Responsible Body

CDTI.

Measure 5.4. Increase, coordination, improvement and efficient use of scientific and technological infrastructure and equipment (example instrument of the State Research Agency)

a) Description:

The identification of synergies and scientific and technical capacity, and the coordination of national infrastructure (ICTS) with the main European research infrastructure (ESFRI) represents one of the strategic vectors of the Spanish RIC policy which enables the available technology for energy services and products to be improved.

b) Objectives

- Promoting the first level of RIC, supported by an advanced network of unique scientific and technical infrastructure existing in Spain (ICTS) and the European network of research infrastructure (ESFRI) in which Spain participates.
- Supporting the development, consolidation and access and use of the research infrastructure by agents of the Spanish System of Science, Technology and Innovation, as well as increasing the interest and participation of the private sector in RIC activities.
- Strengthening the capacity for RIC in the Spanish System of Science, Technology and Innovation, and driving scientific and technical convergence between different regions through the development, maintenance and update of unique scientific and technical infrastructure (ICTS).
- Contributing to the progress of science and technological development through the launch and operation of research infrastructure, facilitating the processing, analysis and use of the data generated and promoting access, processing and storage.
- Driving the interconnection between distributed and virtual research infrastructure (e-infrastructure) and the development of shared advanced services, contributing to European initiatives in this area.
- Supporting the purchase, maintenance and update of the scientific and technical equipment needed for the execution of high-impact, relevant RIC activities.

c) Measures

Aid for infrastructure and scientific and technical equipment through the state programme for promoting knowledge and strengthening science and technology of the RDI system of the State Plan on Scientific and Technical Research and Innovation 2017-2020.

d) Responsible Body

Spanish Research Agency.

Measure 5.5. Public purchasing of green innovations to promote innovation through public demand

a) Description

The public purchasing of innovative technology (CPTI) consists of the public purchasing of goods or services that do not exist at the time of purchase, but that can be developed within a reasonable time period. This purchase requires the development of new or improved technology in order to meet the requirements of the purchaser.

Pre-commercial public purchasing is a procurement of research and development services (R&I), fully paid for by the contracting party, in which the public purchaser does not keep the results of the R&I for its own exclusive use, but shares with companies the risks and benefits of the R&I needed to develop innovative solutions that go beyond what is available on the market.

The public purchasing of innovation is covered by Article 44.3 of Law 14/2011 of 1 June 2011, on Science, Technology and Innovation. Law 9/2017 of 8 November 2017, on Public Sector Contracts (Ley de Contratos del Sector Público, LCSP) created two new procedures intended to promote the public purchasing of innovation: the procedure of ‘partnership for innovation’ and the ‘tendering with negotiation procedure’.

This measure is also aligned with the strategies for smart specialisation to improve knowledge exchange between political agents and the interested parties, above all supporting the participation of SMEs.

b) Objectives addressed

- Developing the capacity of the Administration to act as a driver of business innovation, managing its demand for products and services.
- Promoting innovation from the demand side: in other words, strengthening innovative companies by incentivising the private sector to make proposals of greater added value to provide solutions for strategic projects of the Administration.
- Promoting public-private collaboration
- Improving public services

c) Mechanisms

The public aid that forms part of the State Programme for RDI aimed at the social challenges of the State Plan on Scientific and Technical Research and Innovation 2017-2020 is strengthened through other measures for promoting innovation, based on innovative public procurement instruments. Through the Horizon 2020 programme, the European Commission will subsidise the preparation and achievement of CPP CPTI transboundary groupings.

Specifically, this refers to Aid for the development of innovative products or services in the domain of energy and climate, acquired by public purchasers through the Innovative Public Purchasing (CPP) mechanism.

There are various types of aid at financial level that Spanish public purchasers can select. The currently existing programmes at national level are INNODEMANDA and INNOCOMPRA.

d) Responsible Bodies
CDTI, the Subdirectorate-General for the Promotion of Business Innovation of the Ministry of Science, Universities and Innovation; and the corresponding Public Administrations.

Measure 5. 6. Relaunching the City Foundation for Energy, CIUDEN

a) Description:

The Foundation was created in 2006. It is an organisation independent of the Government of Spain to execute RDI programmes related to energy and the environment and contribute to economic development in the district of El Bierzo (province of Leon).

b) Objectives:

The promotion of economic and social development, and employment in the mining districts of Castile-Leon through research actions and activities on renewable energies and energy efficiency.

c) Measures

- Refocusing research activity (project on the capture, storage and use of CO_2).
- Launching a CIUDEN Plan for economic and technological transformation so that it can play a significant role in revitalising the mining districts of Castile-Leon, acting as body representing the policy of the Ministry for Ecological Transition on the themes it considers necessary to achieve these objectives in other zones.
- Creation of a Strategic Assessment Committee to develop an action plan where the development of new technologies will play an important role and where institutions, companies and local agents will be called on to get involved.

d) Responsible body: MITECO.

Measure 5.7. Information system on Science, Technology and Innovation for monitoring financing

a) Description

Article 11 of Law 14/2011 of 1 June 2011, on Science, Technology and Innovation, establishes the creation of the Information system on Science, Technology and Innovation (hereinafter SICTI) as an instrument for capturing data and analysis for the development and monitoring of the Spanish Strategy on Science, Technology and Innovation, and its development plans.

All the public aid granted under the State Plans for Scientific and Technical Research and Innovation, as well as the information about the beneficiaries of this aid, will be included in the Information system on Science, Technology and Innovation. The State Plans, through the corresponding Annual Action Plans detailing the actions to be carried out over the year, as well as financing planned during this year, will include indicators for monitoring these actions. These monitoring indicators will determine the level of achievement of the defined objectives for each action and may have a short, medium or long-term time span.

b) **Objectives addressed:**

This new instrument will enable detailed monitoring of the resources used for research and innovation on energy and climate, and the real impact achieved.

c) **Mechanisms for action:** Annual Action Programme for RIC activities.

In March each year, the corresponding provisional annual action programme will be provided, including the initially planned actions that will be convened during the year, with their objectives, beneficiaries and description.

In October each year, the final version of the annual action programme for the current year will be provided, including: (a) actions that have already been convened or will be convened this year; (b) the planned budget for each action; (c) the planned dates for the call notices; and (d) the provisional management indicators for each action.

The annual programmes of action will include two types of indicators: (1) management indicators for the activities that will be common to all actions and (2) monitoring indicators to check that the objectives have been achieved.

When the year is complete, all the necessary information for each of the actions of the previous year will be loaded into the Information system on Science, Technology and Innovation, and the final map of the actions called for will be available; as well as the final management indicators for each call notice and the final monitoring indicators for each call notice.

d) Responsible Bodies

The Ministry of Science, Innovation and Universities, through the Subdirectorate-General of Planning, Monitoring and Assessment of RDI in coordination with the ministerial departments with RIC activities.

Measure 5.8. European innovation financing mechanisms

There are a large number of European, national and regional policy programmes and instruments to promote innovation and inter-regional cooperation on energy, and particularly on climate (among others, the investment plan for Europe, the '**Juncker Plan'**, which has the European Fund for Strategic Investment (EFSI) as one of its pillars. The **European Fund for Strategic Investments 2.0** focuses even more on sustainable investment in all sectors in order to contribute to achieving the objectives of the Paris Agreement and help realise the transition to an economy that is efficient in the use of resources, circular and low in carbon. At least 40 % of the EFSI projects under the infrastructure and innovation chapter should contribute to the fulfilment of the EU climate action commitments in line with the objectives of the Paris Agreement. The **InvestEU** programme will strengthen this focus.

In line with initiatives at European level, Spain will test **new financing focuses to support high-risk innovation with a major impact in the domain of clean energy** (such as Priority Technology Initiatives, First of a Kind - FOAK - projects, etc.) in order to promote an entrepreneurial spirit and assimilation by the market of innovative low-carbon solutions that are efficient from an energy perspective.

The **Innovation Fund**, within the framework of the EU emission trading scheme, will support the demonstration on a commercial scale of pilot projects and the most advanced technologies (dedicated to renewable energies, energy efficiency in industry and the Capture and Use of CO_2).

Measure 5.9. International cooperation

Global challenges require a global response based on cooperation between Governments in relation to these matters. For RDI, we note the following mechanisms:

Mission Innovation – Accelerating the Clean Energy Revolution

Spain intends to apply to participate in Mission Innovation (MI) Energy, a global initiative of 23 countries of the European Union to drastically accelerate global innovation on clean energy. As part of the initiative, the participating countries have agreed to try to double investment in the clean energy research and development of their governments in five years, while promoting higher levels of private sector investment in transformative clean energy technologies.

Cooperation with Latin America

Creation of thematic networks and strategic projects for RDI, in cooperation with Latin American countries, in practically all areas of renewable energies, micro-networks and storage. These projects are mainly carried out under the framework of the Ibero-American Programme of Science and Technology for Development (CYTED) or the common interest group of Europe and the Community of Latin American and Caribbean States (EU-CELAC) through joint actions financed by the various financing agencies for science, technology and innovation.

In addition, Spain currently participates in various programmes of technical cooperation and technological development in countries of Latin America and the Caribbean, Asia and Africa in the fields of renewable energies, environment and purification and detoxification of water. Development of a special activity in thematic networks for knowledge exchange and development of strategic projects mainly in the field of renewables and micro-networks.

Spain also participates in the EUROCLIMA programme, a regional programme financed by the European Union that contributes to improving the knowledge of political decision-makers in Latin America on the problems and consequences of climate change. In its current phase, EUROCLIMA+ includes thematic areas such as the resilient production of food aimed at Universities and national and regional research organisations, among other bodies.

Cooperation within the framework of the United Nations

CIEMAT leads Capacity Creation projects within the framework of the United Nations (UNIDO), for the promotion of renewable technologies, energy-efficient systems, mitigation and resilience measures on climate change in Small Island Developing States in the Pacific, the Caribbean, Africa and the Indian Ocean.

As well as the stated measures, to achieve the RIC objectives of the INECP, **coordination with the business sector and the promotion of public-private collaboration is essential.** One of the actors in this context will be the Alliance for Energy Research and Innovation (ALINNE)

The 2008-2011 RDI Plan recognised energy and climate change among the five strategic actions that ‘must be coordinated through specific actions that address a collection of instruments and programmes in an integrated way (human resources, projects, infrastructure, etc.) to achieve the proposed objectives’. In the successive annual work programmes, this commitment was reiterated, emphasising the need to group and coordinate the various programmes in a common strategy, improving coordination both with European programmes and the programmes of the Autonomous Communities. To achieve these objectives, the ALINNE initiative has emerged.

Currently, ALINNE is a non-profit initiative to combine and coordinate efforts among all the agents of the RDI energy value chain to provide a response to the main challenges of RDI policy in the energy sector, contributing to the definition of work guidelines at national and European level.

The consideration of a Strategic Action on Energy and Climate is reviving the source of this initiative, whose activity must be recognised and considered in the definition and execution of the INECP.

4 IMPACT ANALYSIS ON THE POLICIES AND MEASURES IN THE PLAN

Methodology

This summary sets out the main results of the economic, social and public health impact assessment for the Integrated National Energy and Climate Plan 2021-2030 for Spain.

The study, following the Governance Regulation, differentiates between a Baseline scenario (with no additional measures) and a Target scenario (with additional measures). In the Baseline scenario, the greenhouse gas (GHG) emissions in Spain increase by 8 % in 2030 compared to 1990, while they decrease by 20 % in the Target scenario. The impact analysed in this study is the effect of the policies and measures set out in the INECP that make it possible to achieve this target.

The 2030 GDP projections used in this analysis are those prepared by the Ministry of Economy and Enterprise (MINECO). The projections regarding investment costs for renewables, prices of energy goods and CO_2 allowances are those recommended by the European Commission for all Member States for the preparation of their INECPs. The variation in the cost of electricity was estimated by Red Eléctrica de España (REE, the Spanish electricity system operator), based on the data provided by the Sub-Directorate General for Renewable Energy and Studies of the Ministry for Ecological Transition.

To analyse the economic impact of the INECP, information was combined from a series of energy and economic models. Specifically, information about the energy system was taken from the energy model (TIMES-SINERGIA) and the electricity sector model (ROM), which was incorporated into the DENIO economic model. DENIO is a Dynamic Econometric Input-Output model of the Spanish economy, which has its origin in the FIDELIO model (Fully Interregional Dynamic Econometric Long-term Input-Output) from the European Commission's Joint Research Centre (JRC). The model was developed by the Basque Centre for Climate Change, 2019 (BC3), in collaboration with the Centre of Economic Scenario Analysis and Research (CESAR). This model makes it possible to simulate the effect of a wide range of economic, fiscal, energy or environmental policies. DENIO is characterised by a detailed description of the Spanish economy in terms of productive sectors (74 sectors and 88 products), households (22 000 representative households of the Spanish population) and 16 categories of consumption. The model also includes detailed public sector accounts, including the income and expenditure of the public administrations (PAs), the deficit and public debt. This model was estimated econometrically using the latest data available from the National Statistics Institute (INE), the Bank of Spain and EUROSTAT. The model has been used to calculate the economic impacts: GDP, employment by sector and gender, consumption, tax revenue, trade balance; and social impacts: economic impacts by household type, inequality, energy poverty, resulting from both the investments and the changes in the energy system (energy mix, efficiency, energy prices) associated with the INECP.

In addition, the information about the changes in air pollutant emissions generated by variations in the energy system from the INECP (obtained by the Inventory Unit of the Ministry for Ecological Transition [MITECO]), was entered in the **TM5-FASST air quality model**. The TM5-FASST model is a global model also developed by the JRC that makes it possible to analyse the effects, in terms of health, resulting from different emissions scenarios or paths. Using meteorological and atmospheric chemistry information, the model analyses how the atmospheric emissions from a certain source generate concentrations of pollutants, exposure in the population and, consequently, damage to health and premature deaths. The model has been used by BC3 to carry out studies at global level on mitigation and co-benefits for health. Moreover, inter alia, it has been used by the OECD to project the economic costs associated with air pollution. For this work, the model has been calibrated to be consistent with the damage to health reported by the World Health Organization (WHO) for Spain.

Investments from the INECP 2021-2030

A very significant part of the economic impacts results from the additional investments associated with the Plan. These investments have been quantified using different sources. The investments associated with the energy efficiency and energy saving measures and those related to the promotion of thermal renewables are from the Institute for Energy Diversification and Saving [Instituto para el Ahorro y la Diversificación Energética – IDAE]. The investments associated with renewables in the electricity sector come from estimates made by the Sub-Directorate General for Renewable Energy and Studies using the TIMES-SINERGIA model. The information on investments in transmission and distribution networks and interconnections comes from different sources, including Red Eléctrica de España. The information regarding the investment of the non-energy diffuse sectors comes from the Spanish Office for Climate Change [Oficina Española de Cambio Climático]. The appropriate estimations have been made for any matters regarding which there was no information, as is the case of the investments in recharging points or investments associated with the electrification of transport.

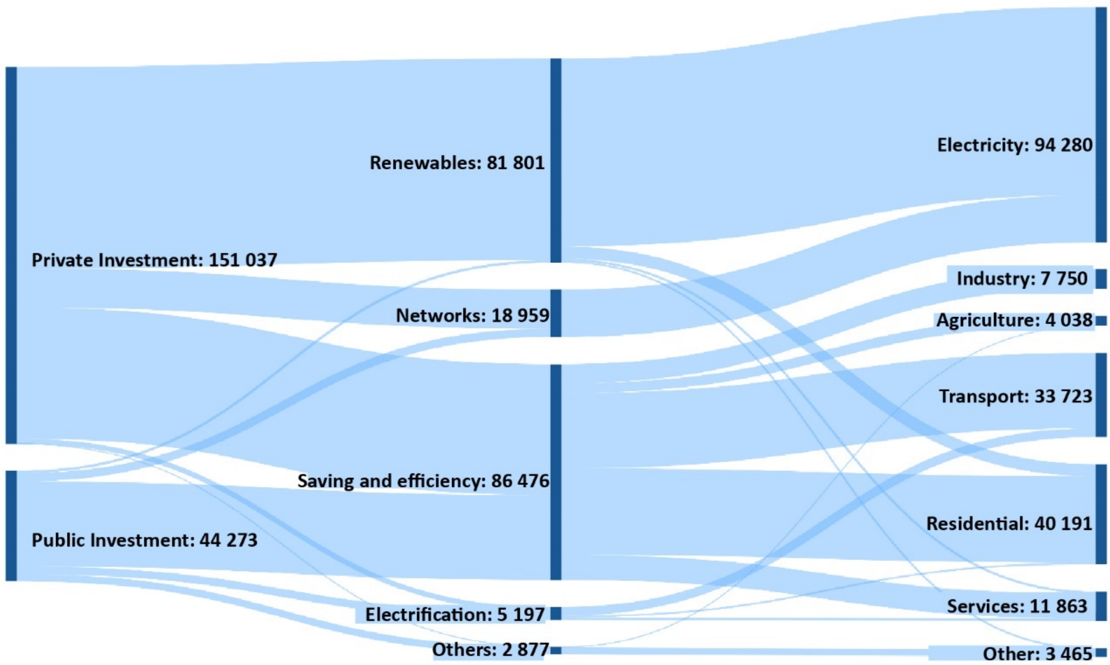
Once this information is added, it is estimated that **the total investments to achieve the INECP targets will amount to EUR 236.124[50] billion (€ bn) between 2021 and 2030**. These investments can be grouped by measures or core parts of the energy transition, and will be distributed as follows:

- Saving and efficiency: 37 % (€86.476 bn)
- renewables: 42 % (€101.636 bn)
- Networks and electrification: 18 % (€41.846 bn)
- Other measures: 3 % (€6.166 bn)

Of these total investments, €195.31 bn can be considered as additional investments with respect to the baseline (see Figure 4.1). These additional investments are those that can be imputed to the INECP and those that will therefore generate the economic impact. The total and additional investments differ because in the Baseline scenario there are also investments such as in the case of renewables in the electricity sector, for example, where an installation with new renewable capacity (20 GW) is being considered to meet the increase in demand and the investments in associated networks.

[50]These figures do not include the specific investments in thermal renewables in the industrial sector and agricultural sector. Investments in rail transport have not been considered either.

Figure 4.1. Flow of investments from the INECP 2021-2030



Source: Basque Centre for Climate Change, 2019, 2018.

Taking the source of the investments into account, a very substantial part of the total investment is made by the **private sector (80 % of the total)**, mainly linked to the deployment of renewables, distribution and transmission networks, and a large part of the saving and efficiency measures. The rest would be made by the public sector (20 % of the total), in energy saving and energy efficiency measures, electrification of the economy and in actions associated with promoting sustainable mobility and modal shift. In the case of public sector investments, one part (around 5 % of the total investment) would come from European funds.

Results

The results obtained come from adding the flow of additional investments, the energy mix and the energy prices from the TIMES-Sinergia model to the DENIO model.

Before explaining the main results, it is important to make three preliminary considerations:

- The investments made using public funds (except investment from European sources) must be financed using other budget lines so that they make it possible to maintain the budgetary equilibrium. The analysis done has been included in the deficit-reduction path agreed in the Stability and Growth Pact, which entails reducing the deficit to zero in 2022 and then maintaining the budgetary equilibrium to also reduce the public debt on the path set out to 2032.

- In the case of households, it is assumed that the total amount of indebtedness remains constant and, therefore, the additional investments made by households are financed through savings or by reducing spending.

- It is considered that there are no restrictions on investment for companies and that investment will take place at the usual cost of capital. This is compatible with medium- and long-term regulation and planning that provides security and certainty to investors. Moreover, it is considered that these additional investments do not 'crowd out' other investments from the private sector. This is consistent with the current situation in Spain, which has a high idle capacity and high unemployment rate, and, in general, with the situation in the European Union, which has historically low interest rates.

- Finally, the study assumes that the degree of external competitiveness does not change. In other words, companies maintain a capacity to respond to market conditions that is similar to the current one, not higher or lower, in a context where other neighbouring countries are also introducing policies geared towards complying with the Paris Agreement. To that end, it is assumed that relative prices between Spain and the rest of the world remain constant. The proportion between domestic production and imports per product also remains fixed.

Macroeconomic impacts

The macroeconomic impacts are determined by two main effects. The first is the 'new investment' effect, which generates an economic boost throughout the supply chains. The second is the effect resulting from the 'energy shift': this includes the economic boost resulting from the energy saving, which makes it possible to increase spending on other products and services, and from the shift in the energy mix, which replaces imported fossil fuels with renewables, generating greater added value within the country.

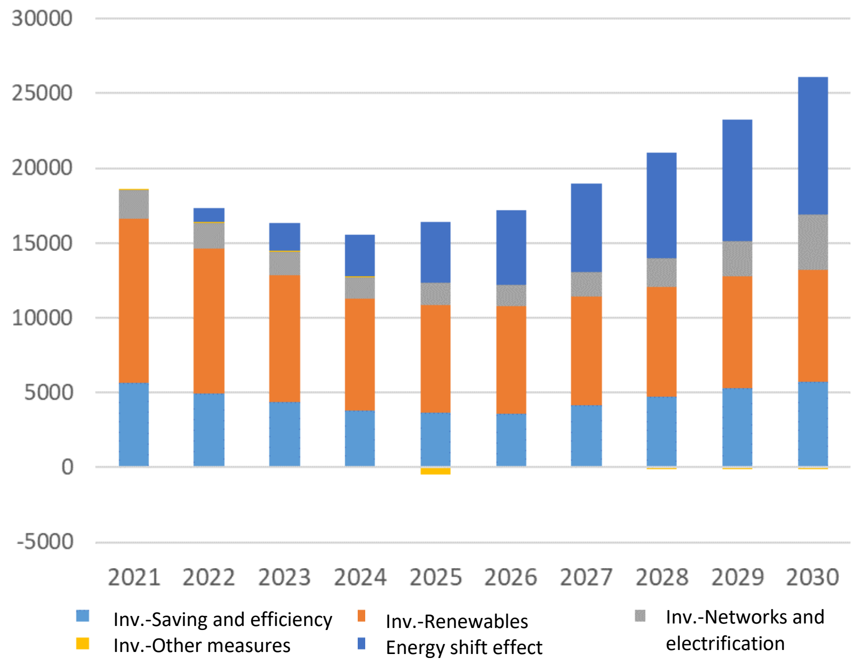
- The **'new investment'** effect produces a very notable impact, especially in the initial yeas of the plan. It is important to note that not every investment turns into added value and job creation, since one part (around 20 % and depending on the sectors) requires goods that are imported, something the model allows for capturing in detail and that is included in the results. Moreover, the impact of the investments is not permanent, but rather will only have an effect during the years in which they are made.

- The **'energy shift' effect** also creates an effect that is more pronounced towards 2030, when the policies are reducing energy consumption and energy prices are higher. In fact, the importation of fossil fuels decreases by EUR 75.379 bn between 2021 and 2030. These impacts, unlike those associated with the investments, do remain over time.

Figure 4.2 shows the effect on GDP disaggregated by measure type; the impact of the INECP is the difference between the GDP in the Target scenario compared to the Baseline.

The INECP will generate an increase in GDP between EUR 19.3 and 25.1 bn per year (1.8 % of GDP in 2030). The positive impact comes mainly from the economic boost generated by the new investments in renewables, saving and efficiency and networks. In the case of renewables, the impact decreases throughout the plan as the investments decrease and they represent an increasingly small percentage of the GDP. By contrast, the effects resulting from the energy shift generate an increasingly positive impact.

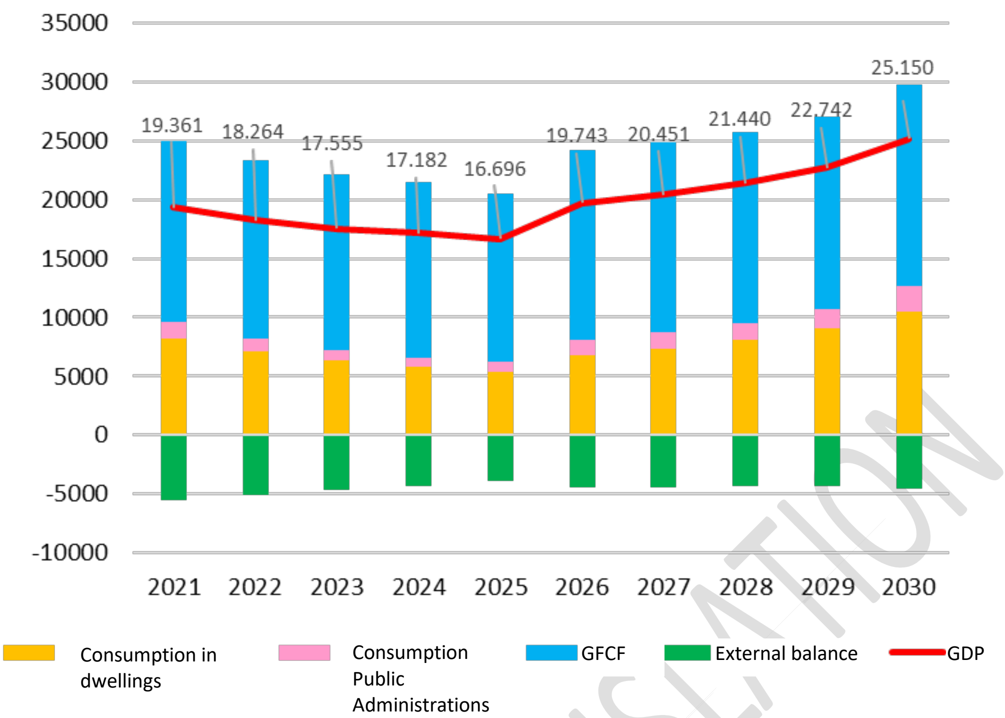
Figure 4.2. Impact on GDP by measure type (€ m)



Source: Basque Centre for Climate Change, 2019.

Figures 4.3, 4.4 and 4.5 show the impacts on GDP from the demand side, supply side and income side. The GDP by demand side (Figure 4.3) shows that the increase in GDP is mainly channelled towards gross fixed capital formation (GFCF), as could be expected given the investments considered in the plan. Household final consumption also increases steadily since the increase in GDP resulting from the investments generates an increase in compensation of employees and in the gross operating surplus, which, in turn, has a positive impact on household disposable income and household consumption. There is also a positive impact in the case of public administration consumption as the increase in tax revenue makes it possible to increase public spending, keeping the public deficit constant. Finally, the negative external balance simply reflects the closing hypothesis of the chosen model in which exports remain constant in the Target scenario, while imports grow thanks to the increase in economic activity. The exception is energy imports, which also decrease due to lower domestic consumption of coal and oil.

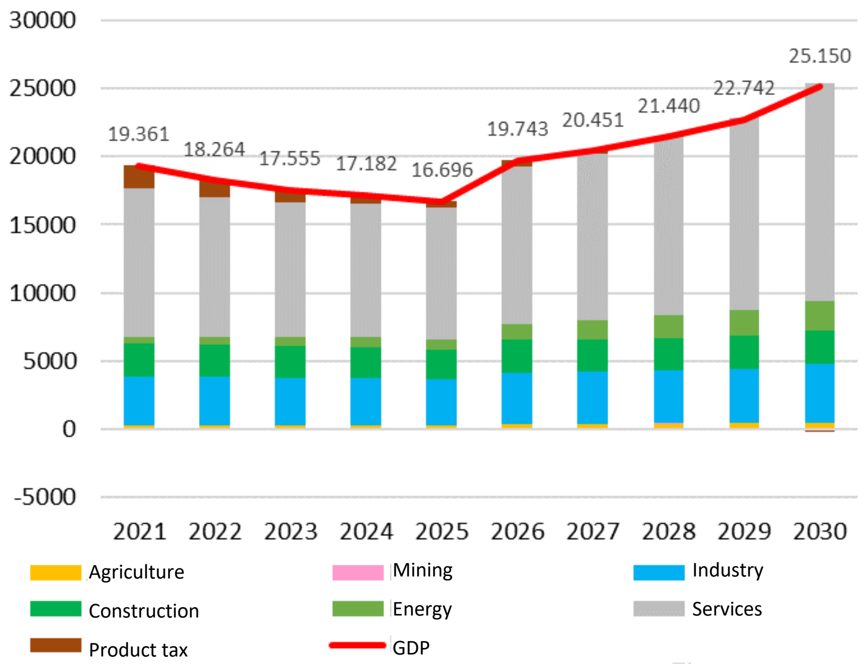
Figure 4.3. Impact on GDP: demand (€ m)



Source: Basque Centre for Climate Change, 2019.

Figure 4.4 shows the change in GDP based on the supply side, allowing us to see the sectors where this increase in added value originates. Firstly, a net increase should be noted in all major sectors, with the sole exception of the mining sector. The added value of the industrial sector grows substantially (between EUR 3.5 bn in 2021 and EUR 4.2 bn in 2030), mainly boosted by the deployment in renewables, networks and electrification of transport and renewal of the vehicle fleet. The energy sector also increases its activity due to replacing imported energy with indigenous renewable energy (between EUR 500 m and EUR 2.1 bn). The value added of the construction sector also increases notably (between EUR 2.4 bn in 2021 and EUR 2.5 bn in 2030) as a result of the investments in housing upgrades and the deployment of all the infrastructure needed to deploy renewables or electric vehicles. Finally, as is logical, the service sector takes up a significant part of the increase in the added value given its weight in the Spanish economy (it represents 65 % of the GDP). This increase in the service sector is explained by the increase in the services directly associated with the plan, and also by the indirect and knock-on effect resulting from the increased economic growth.

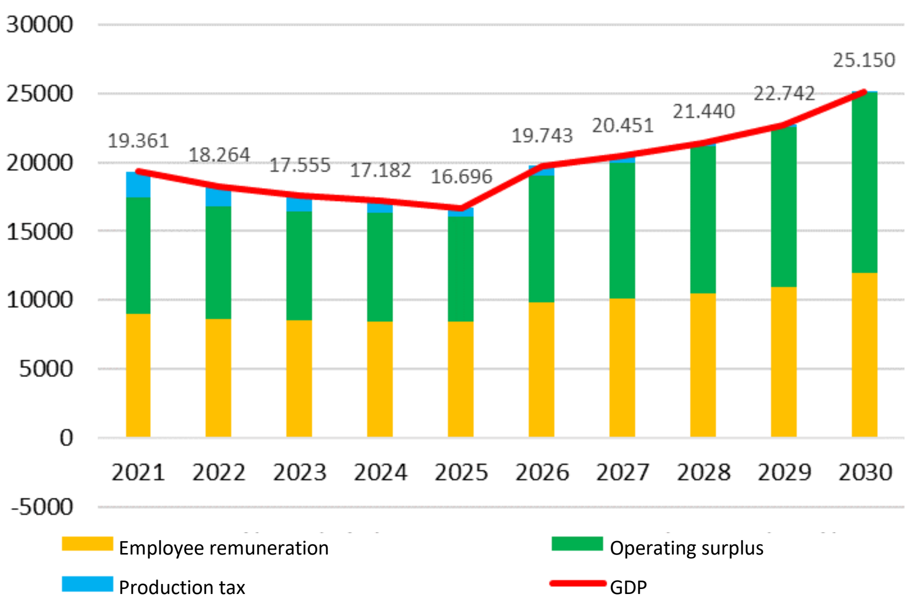
Figure 4. 4. Impact on GDP: supply (€ m)



Source: Basque Centre for Climate Change, 2019.

Finally, the impact on GDP based on the income side (Figure 4.5) allows us to see the distribution of income generated between capital and labour. Gross operating surplus increases notably (between EUR 8.4 bn and EUR 13 bn) since part of the impact comes from investments channelled towards capital-intensive industries (industry, construction, energy). Employee remuneration also increases very significantly (between EUR 9 bn and EUR 12.2 bn), mainly as a result of job creation. Finally, it should be noted that the gross operating surplus also includes mixed incomes that include the income from small or individual enterprises and also from self-employed persons.

Figure 4.5. Impact on GDP: income (€ m)

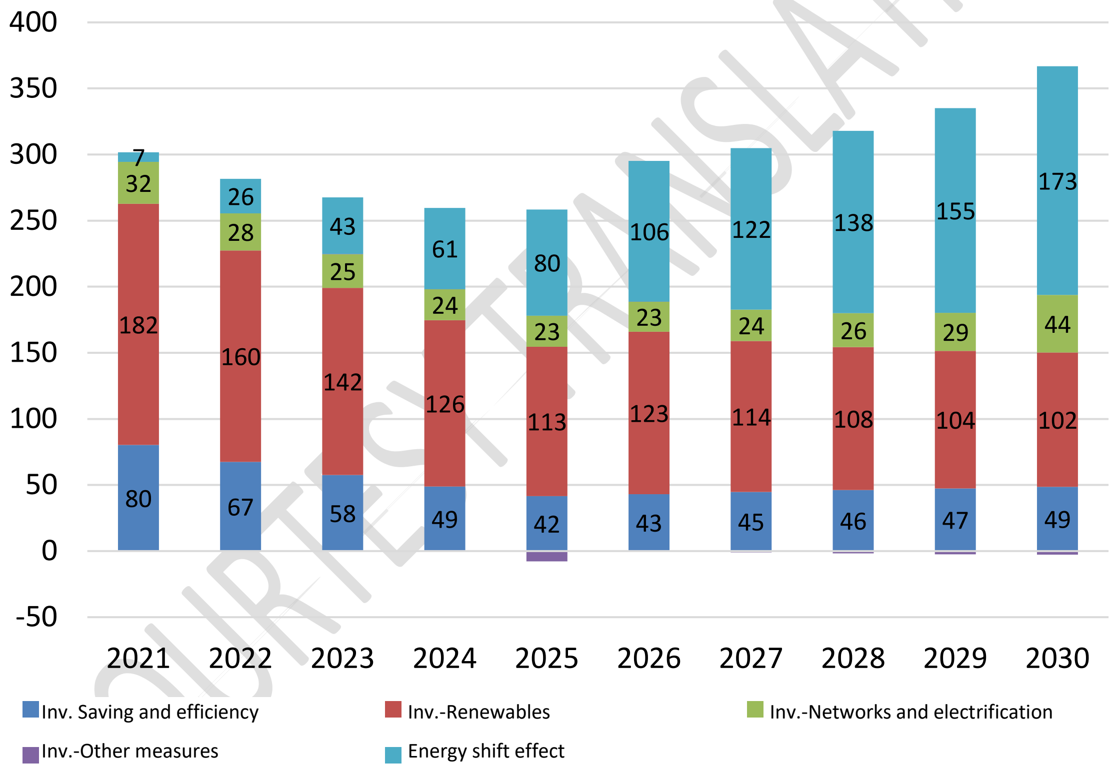


Source: Basque Centre for Climate Change, 2019.

Figure 4.6 shows the effect on employment between the Target scenario and the Baseline disaggregated by measure type. **The INECP generates a net increase in employment between 250 000 and 364 000 people per year (a 1.7 % increase in employment in 2030).** The unemployment rate would decrease compared to the Baseline scenario, between 1.1 % and 1.6 %. As in the case of the impact on GDP, the employment comes from the new investments in renewables, saving and efficiency and networks and, from 2025, the effect resulting from energy shift.

Investments in renewables would generate between 102 000 and 182 000 jobs/year, while investments in energy saving and efficiency would generate between 42 000 and 80 000 jobs/year. Investments in networks would generate between 23 000 and 44 000 jobs/year. Energy shift would indirectly generate up to 173 000 jobs/year in 2030. Finally, the negative impact associated with disinvestments is also shown, considered in nuclear power plants and coal from 2025 and in relation to the Baseline.

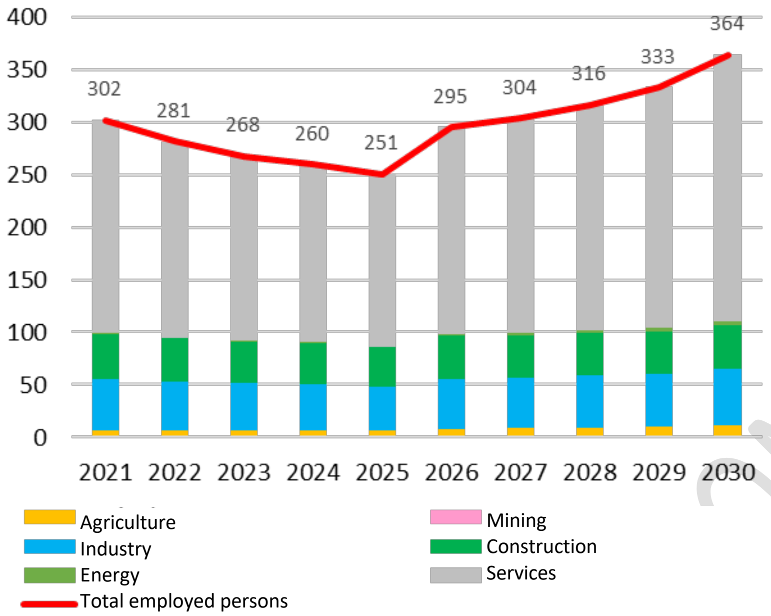
Figure 4.6. Impact on employment by measure type (thousands of people/year)



Source: Basque Centre for Climate Change, 2019.

Figure 4.7 shows the net jobs generated by major sectors. As in the case of GDP, net employment is positive, except in the case of the mining sector. Employment in the industrial sector increases by 48 000 to 53 000 people/year, while in construction it increases by 37 000 to 42 000 people/year. Finally, employment in the service sector increases in a more notable way, by 165 000 to 250 000 people/year, as a result of the services associated with the new investments and due to the shift in consumption structure.

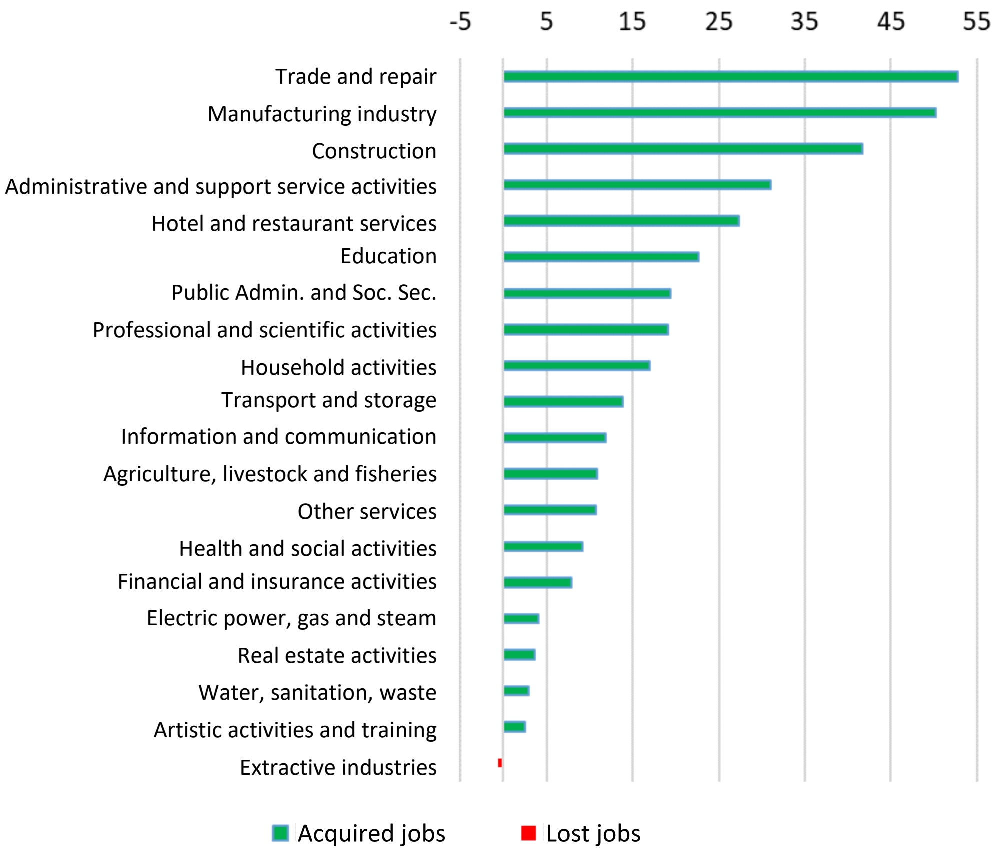
Figure 4.7. Impact on employment by sector (thousands of people/year)



Source: Basque Centre for Climate Change, 2019.

Figure 4.8 shows the impact on employment in 2030 for the industries in the national accounts. The industries that would generate most employment would be trade and repair (52 700 employees), manufacturing industry (50 200 employees) and construction (41 700 employees). The electricity sector would have net job creation (4 100 employees), including the loss of employment associated with the decrease in activity in coal and nuclear plants. The only industry, according to this aggregation, that obtains a net loss of employment is mining and quarrying (569 jobs), resulting from the decrease in coal mining activity.

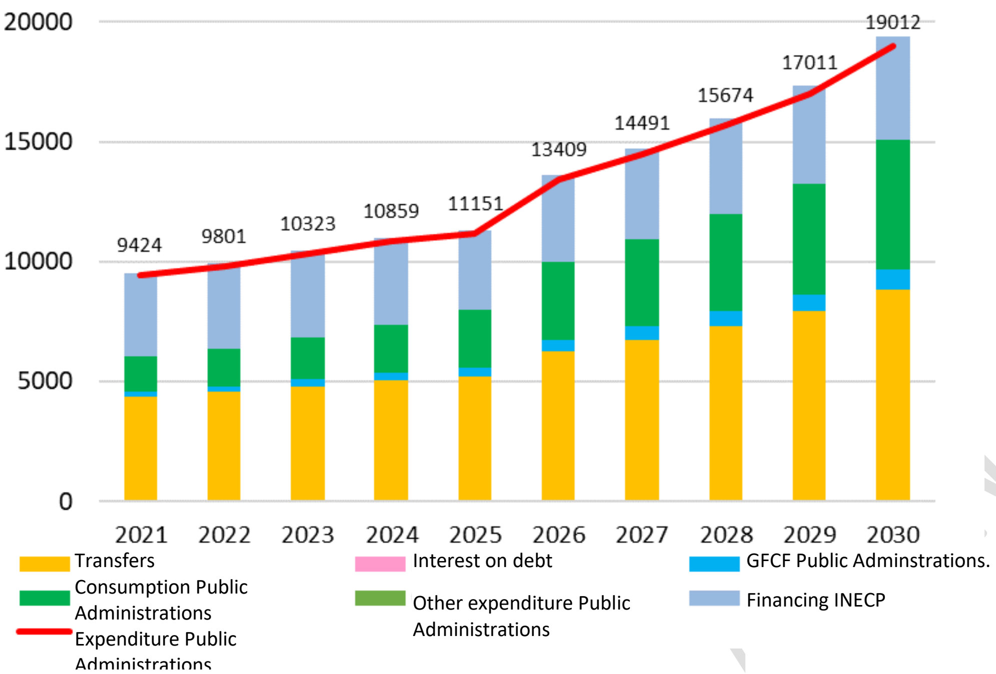
Figure 4.8. Impact on employment by industry (thousands of people/year)



Source: Basque Centre for Climate Change, 2019.

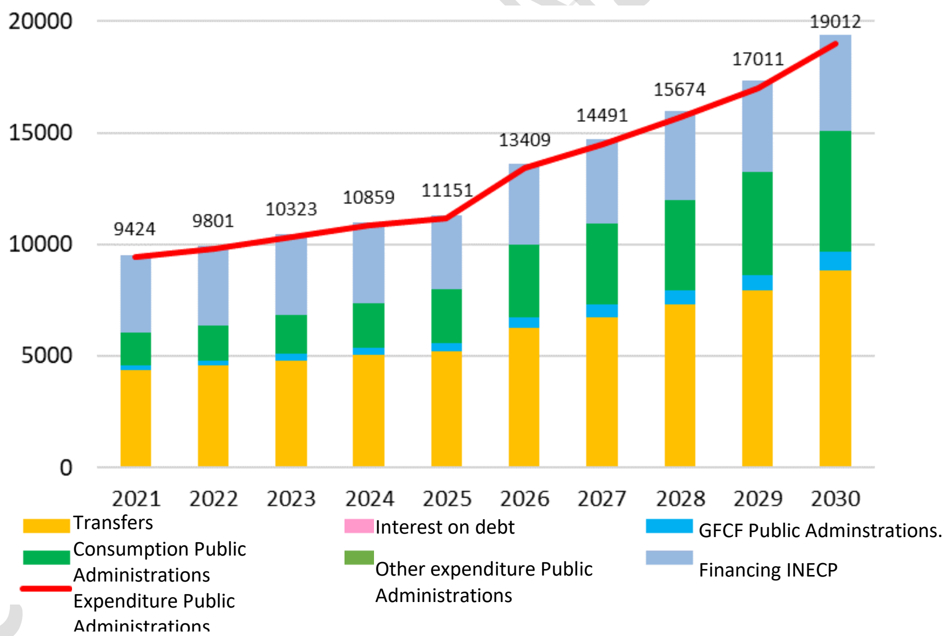
Finally, Figures 4.9 and 4.10 show the economic impact on the public administration accounts. Figure 4.9 shows how expenditure would increase between EUR 9.4 bn and 19 bn (at current prices). This expenditure includes spending linked to the INECP (between EUR 3.473 bn and EUR 4.3 bn) and any additional spending resulting from the increase in tax revenue generated by the Plan itself. Although the revenue would decrease for some taxes, such as taxes on energy, this would be offset by an increase in revenue through other channels. In particular (see Figure 4.10), taxes on income, wealth and capital would increase by between EUR 4.1 bn and EUR 11.3 bn, and contributions to Social Security between EUR 2.9 bn and EUR 6 bn.

Figure 4.9. Impact on public administration (PA) accounts: expenditure (EUR million)



Source: Basque Centre for Climate Change, 2019.

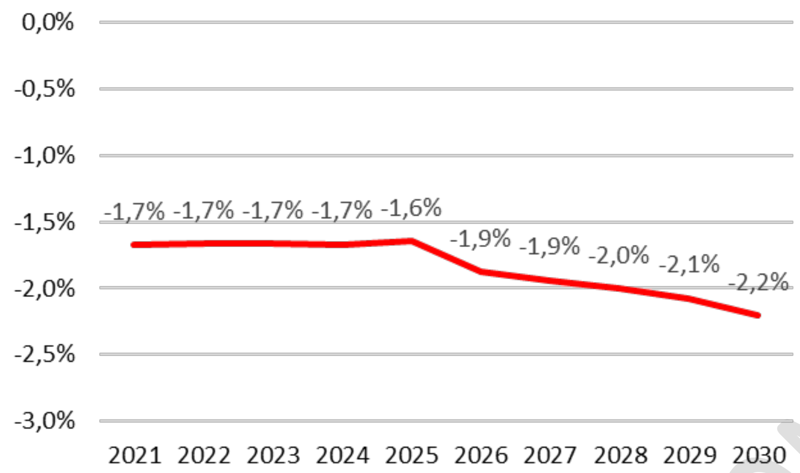
Figure 4.10. Impact on public administration (PA) accounts: income (EUR million)



Source: Basque Centre for Climate Change, 2019.

It is important to note that the increase in public spending is exclusively due to the plan's knock-on economic impact, as one of the constraints that have been introduced is compliance with the Stability and Growth Pact. In fact, compliance with the deficit path combined with the higher level of economic activity allows the ratio between debt and GDP to decrease by 2.2 % in 2030 compared to the baseline scenario (Figure 4.11).

Figure 4.11. Debt/GDP ratio (% compared to baseline)



Source: Basque Centre for Climate Change, 2019.

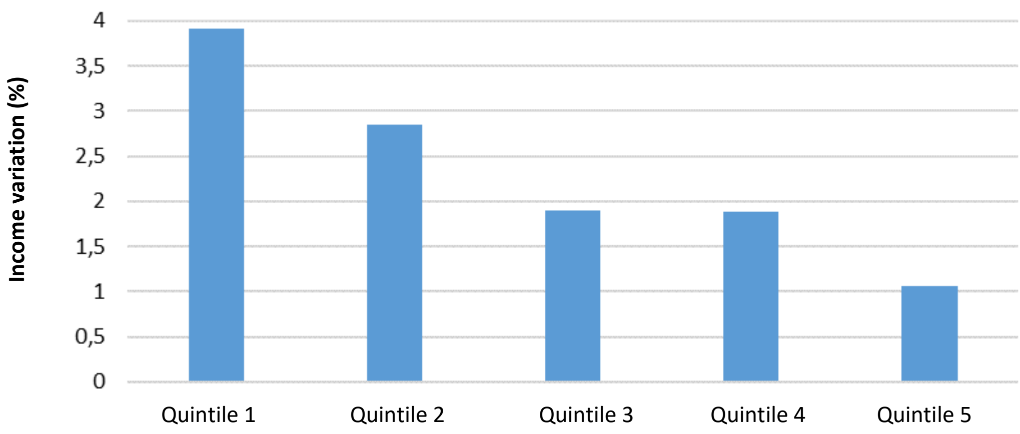
Social impacts

In the case of the social impacts, the results obtained for a whole set of indicators allows us to conclude that the measures[51] in the INECP favour households with a lower income and, especially, vulnerable groups.

Figure 4.12 shows the effect on household disposable income by income quintile ratio, where quintile 1 groups the 20 % of households with the lowest income and quintile 5 the 20 % of households with the highest. The figure shows that the measures in the INECP have a progressive effect. Disposable income increases in all quintiles, but it increases to a greater extent in the quintiles with lower income, due in part to the effects of the aid for housing upgrades, which has a more positive effect on these groups. Quintiles 1 and 2 see an increase in their disposable income by 3.9 % and 2.8 %, while quintiles 4 and 5 increase their income by 1.9 % and 1.1 %, respectively.

[51] The policies analysed in the INCEP have included the design (preliminary and by BC3) of some measures with redistributive impact such as aid related to housing upgrades, the promotion of self-consumption in vulnerable households or extending the current special heating discount ('bono de calefacción').

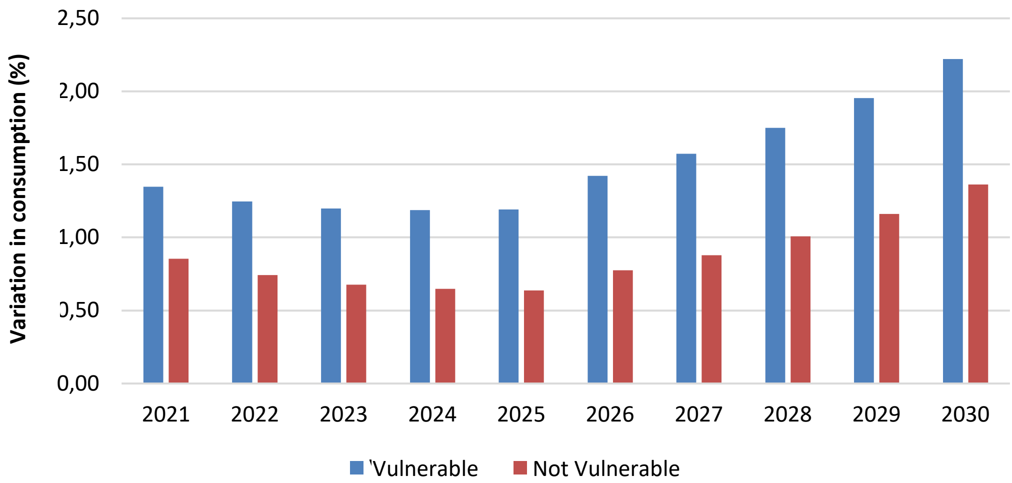
Figure 4.12. Variation in disposable income in 2030 by income quintiles (%)



Source: Basque Centre for Climate Change, 2019.

Figure 4.13 shows the effect of the INECP on the spending of vulnerable households, as defined in Royal Decree-Law 15/2018 of 5 October 2018. The figure shows an increase in spending of both vulnerable households and non-vulnerable households, with the effect on vulnerable households being more positive as they benefit in a more significant way, not only from the energy saving and reduction of their energy bill, but also due to the aid associated with the plan and channelled towards lower-income households. Vulnerable households increase their spending by 2.2 % and non-vulnerable households increase it by 1.3 % in 2030.

Figure 4.13. Variation in final consumption between vulnerable and non-vulnerable households (%)



Source: Basque Centre for Climate Change, 2019.

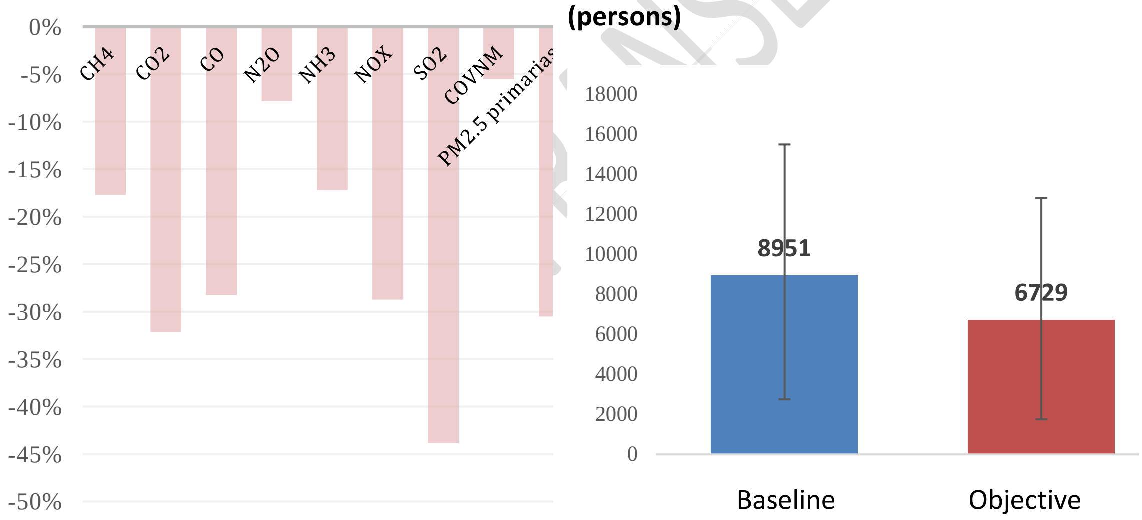
Impacts on pollution and public health

According to the World Health Organization (WHO), in 2010 there were a total of 14 042 premature deaths caused by air pollution in Spain. The pollutants that caused the most effects on health are fine particulate matter ($PM_{2,5}$) and ozone (O_3). $PM_{2,5}$ emissions are the leading cause of premature death resulting from pollution, causing problems in the respiratory (lung cancer), cardiovascular or brain (ischemic attacks) systems. As regards ozone (O_3), although it is usually associated with damage to farming systems, it also produces significant effects on health, related to respiratory diseases.

The measures set out in the INECP manage to reduce both GHG emissions and those of the leading primary pollutants that generate final concentrations of $PM_{2,5}$ and O_3. Figure 4.14 shows the decrease in emissions by pollutant calculated by the MITECO Inventory Unit based on the new energy mix.

Figure 4.11. Change of emissions in 2030 in relation to the Baseline scenario (a) and premature deaths in Spain resulting from air pollution in 2030 (b)

a) Change of emissions (%) **b) Premature deaths due to air pollution (persons)**



Source: Basque Centre for Climate Change, 2019.

Primary emissions of $PM_{2,5}$, the most harmful to health, decrease by 31 % as a result of using cleaner technologies. Moreover, sulphur dioxide (SO_2) and nitrous oxides (NO_x), the main pollutants for the formation of secondary $PM_{2,5}$, decrease by 44 % and 29 % respectively. The reduction of SO_2 is mainly due to the decrease in coal consumption in the electricity sector, and in the case of NO_x due to the improvement in the efficiency of internal combustion engines and electrification.

These reductions in the emission levels of air pollutants are associated with significant improvements in terms of environmental quality, which translate into a reduction of damage to health in terms of premature deaths. As Figure 4.11b shows, premature deaths due to air pollution in 2030 decrease by 2 222 people, going from 8 951 in the Baseline scenario to 6 729 in the Target scenario. This 25 % decrease in percentage terms would be in a range between 17 % and 36 % if we used the extreme values from the figure.

Sensitivity analysis

This section sets out a sensitivity analysis of the economic impact of the INECP at the fossil fuel prices as at 2030 recommended by the European Commission used for this study. The sensitivity analysis has only been done on the DENIO model.

In the sensitivity analysis, we compared this central scenario of the European Commission with two other alternative scenarios with a range of +/-25 % in all fossil fuel prices. For example, in the case of oil, and according to the International Renewable Energy Agency (IRENA), a scenario complying with the Paris Agreement would mean a 20 % overall reduction in oil consumption as at 2030 compared to current levels, a drop in demand that should contain the rise in prices. However, other organisations such as the International Energy Agency (IEA) indicate that there could currently be an investment 'gap', which could reduce the supply and push up prices. This sensitivity analysis makes it possible to evaluate a greater range of future solutions regarding which there is high uncertainty.

Table 4.1 sets out the results regarding GDP and the macroeconomic picture. It is observed that a lower increase in fossil fuel prices means a reduction of the impact in terms of GDP, and vice versa. A 25 % reduction in prices compared to those in the central scenario generates a 16 % reduction of the Plan's impact in GDP terms, while a 25 % increase entails an increase of 8 %.

The change in fossil fuel price ultimately affects the reduction of energy bills resulting from the saving and efficiency measures. Thus, the forecast savings on energy bills will be greater in a high energy price environment, which will enable higher consumption growth, which in turn will generate an increase in investments not associated with the plan and also in tax revenue and public consumption. The opposite would occur in a low price environment.

Table 4.1. Sensitivity analysis of energy price on GDP in 2030, Target scenario compared to Baseline (€ m)

	Scenario p -25 %	Scenario Central	Scenario p +25 %
GDP	21 07	25 15	27 25
Private Consumption	6 470	10 50	12 90
Public Consumption	1 046	2 135	2 678
Gross Fixed Capital	16 46	17 08	17 37
Exports	0	0	0
Imports	2 905	4 580	5 698

Source: Basque Centre for Climate Change, 2019.

Table 4.2 shows the results in terms of employment by major categories of sectors. Net job creation would go from 364 000 people/year in the central scenario in 2030 to a range between 329 000 and 378 000. A 25 % reduction in price generates a 10 % reduction in job creation, while a 25 % increase entails an increase of 4 %. The reasons behind this higher/lower increase are the same as those mentioned with regard to GDP.

Table 4.2. Sensitivity analysis of energy price on net employment in 2030, Target scenario compared to Baseline (thousands)

	Scenario p -25 %	Scenario Central	Scenario p +25 %
Total	329	364	378
Agriculture and fisheries	11	11	11
Mining	-1	-1	0
Industry	51	54	55
Construction	39	42	43
Energy	5	4	5
Services	224	254	265

Source: Basque Centre for Climate Change, 2019.

Finally, it is important to note that the future prices of fossil fuels will not only have an effect through the effect on the energy bill, they will also have an effect, for example, on the energy mix, on the degree of profitability of the investments or on other variables, such as the GDP growth itself assumed in the Baseline scenario, something that is outside the scope of this sensitivity analysis.

Conclusions

The INECP 2021-2030 represents a 20 % decrease in greenhouse gas (GHG) emissions for Spain compared to 1990 levels (Kyoto base year). The macro-economic impact of the INECP analysed is positive as the following figures highlight:

- Total investments mobilised: EUR 236 bn between 2021 and 2030.
- Fossil fuel imports: reduction of EUR 75 bn accumulated between 2021 and 2030.
- GDP: increases by EUR 19.3 to EUR 25.1 bn/year (+1.8 % GDP in 2030)
- Net employment: increases by 250 000 to 364 000 jobs/year (+1.7 % in 2030)

The INECP also favours lower-income households and vulnerable groups. Finally, air pollutants would be reduced, and with it premature deaths, between 17 % and 36 % compared to the Baseline scenario.

ANNEX A. CURRENT SITUATION AND PROJECTIONS: BASELINE SCENARIO AND TARGET SCENARIO

A1 PROJECTED EVOLUTION OF MAIN EXOGENOUS FACTORS INFLUENCING ENERGY SYSTEM AND GHG EMISSION DEVELOPMENTS

This first section outlines the main macroeconomic variables that were considered in the foresight exercise that was done in the Plan, following as far as possible Regulation 2018/1999 on the Governance of the Energy Union and Climate Action.

Macroeconomic forecasts: GDP and population growth

The projection of the GDP variable was provided by MINECO, updated to the latest revision of the 2018 Stability Programme. The values are in the table below.

Table A.1. Projection of Spain's GDP

Projection of Spain's Gross Domestic Product (€ bn at constant 2016 prices)				
Year	**2015**	**2020**	**2025**	**2030**
GDP	1.071	1.223	1.334	1.421

Source: Ministry of Economy and Enterprise

The projection of the GDP beyond the horizon set out in the stability programme corresponds to the macroeconomic scenario, established based on the Spanish economy's input-output tables. This scenario, which forecasts 16 % growth in GDP in the decade 2020-2030, uses as starting point the population trend set out in the European Commission report *The 2018 Ageing Report: Economic and Budgetary Projections for the EU Member States (2016-2070)* [52].

The population projection set out in the Plan is the one included in the abovementioned 2018 Ageing Report, in order to thus ensure consistency between the GDP and population projections. As can be observed in the table below, the Spanish population will undergo 1 % growth in the next decade.

Table A.2. Spanish population projection

Spanish population projection (Thousands of persons)				
Year	**2015**	**2020**	**2025**	**2030**
Population	46 450	46 582	46 803	47 155

Source: European Commission

The number of dwellings is projected on the basis of the above population projections, using the INE's persons per dwelling occupancy rate, and assuming a slight increase in future.

In addition to the above, it is estimated that the total households match the total dwellings. In other words, it is considered that all dwellings are inhabited. This hypothesis was prepared taking into account that this study is carried out to project energy consumption in future, and the main consumption situations will be in inhabited dwellings.

The development of total number of dwellings is shown below.

[52] This report can be accessed via the following link: https://ec.europa.eu/info/sites/info/files/economy-finance/ip065_en.pdf

Table A.3. Projection of the number of dwellings

Projection of the number of dwellings (thousands of dwellings)				
Year	**2015**	**2020**	**2025**	**2030**
Number of dwellings	18 346	18 530	18 736	18 999

Source: European Commission, Spanish National Statistical Institute (INE).

It should be pointed out that the number of dwellings includes rehabilitated, new and existing dwellings, assuming different hypotheses for the Baseline scenario and the Target scenario. The details of the measures associated with the upgrade of dwellings are available in chapter A3 regarding the dimension energy efficiency.

Sectoral changes expected to impact the energy system and GHG emissions

No notable sectoral changes are expected according to the macroeconomic scenario produced by MINECO. The table below shows the relative weight of the major sectors of the Spanish economy with regard to the total. Despite the fact that only values in the year 2030 are shown in the table below, these percentages remain practically constant throughout the entire period analysed.

Table A.4. Percentage of the total gross value added for Spain in the year 2030 that corresponds to each economic sector

Representativeness of the economic sectors with regard to the total gross value added for the year 2030	
Agriculture	3 %
Industry	17 %
Construction	8 %
Services	72 %

Source: Ministry of Economy and Enterprise

Global trends, international fossil fuel prices, EU ETS carbon price

The Spanish energy system falls within the global trends and energy markets, and therefore the baseline variable values considered were those recommended by the European Commission.

The values used for the international fossil fuel prices, and their projections up to 2030, are presented below.

Table A.5. International fossil fuel prices

International fossil fuel prices (€ at constant 2016 prices/barrel of oil equivalent)				
Year	**2015**	**2020**	**2025**	**2030**
Oil	46.65	69.17	91.47	100.77
Gas	40.40	44.15	56.08	60.99
Coal	11.71	16.58	18.36	22.04

Source: European Commission

In line with the fuel price development hypothesis from the table above, the European Commission also provided international prices for projecting the cost of emission allowances.

In the case of CO_2 emission allowances traded in the European market system (ETS), the development of its prices is an exogenous variable in the model, and therefore the recommended parameters were used, presented in the table below.

Table A.6. Projection of CO_2 emission allowance cost[53]

International prices of greenhouse gas emission allowances (Units: € at constant 2016 prices/tCO_2)				
Year	**2015**	**2020**	**2025**	**2030**
Emission allowance cost	7.8	15.5	23.3	34.7

Source: European Commission

Technology cost developments

TIMES-SINERGIA, the analytical model used to project the energy system, is a bottom-up model, so the costs of the different energy technologies are a fundamental input for making an appropriate projection of the model's different output variables.

The data provided by the European Commission's JRC were given priority in order to ensure the consistency of the relative prices between the different technologies in the Capacity model. Commonly accepted international sources were used for any data not available from the two sources cited, adapting the values where appropriate to the usual typology in the Spanish energy system.

[53] Data recommended by the European Union for the Baseline scenario. Values from the 'Recommended EU ETS carbon prices' are applied.

A.2 DIMENSION DECARBONISATION

Once the main exogenous variables have been explained, the Baseline and Target scenarios are then described for the different dimensions included in the Plan. This section begins with decarbonisation, which in turn comprises two areas: GHG emissions and promotion of renewable energy.

A.2.1 Greenhouse gas emissions and removals

The target of reducing GHG emissions by 20 % compared to 1990 is a key element in the design of the INECP and determines some of the results that are seen in the other dimensions, influencing, for example, the target of final energy generation using renewables or the increase in the energy efficiency of the national energy system.

For more details about GHG emissions, please see the end of this annex.

The table below shows the total GHG emissions corresponding to the Baseline and Target scenarios of the INECP, detailed by sector.

Table A.7. Total emissions projection in the Baseline scenario

Emissions projection in the Baseline scenario (thousand tonnes of CO_2 equivalent)						
Year	**1990**	**2005**	**2015**	**2020**	**2025**	**2030**
Transport	59 199	102 310	83 197	89 851	91 888	92 131
Electricity generation	65 864	112 623	74 051	58 750	42 064	40 900
Industrial sector (combustion processes)	45 099	68 598	40 462	42 046	42 204	41 218
Industrial sector (emissions from processes)	28 559	31 992	21 036	21 520	22 043	22 451
Residential Commercial and Institutional Sectors	17 571	31 124	28 135	29 304	29 166	27 710
Livestock farming	21 885	25 726	22 854	23 218	23 167	23 116
Crops	12 275	10 868	11 679	11 404	11 412	11 419
Waste	9 825	13 389	14 375	13 832	13 060	12 209
Refining industry	10 878	13 078	11 560	12 592	12 974	13 356
Other energy industries	2 161	1 020	782	734	755	763
Other sectors	9 082	11 729	11 991	14 169	14 563	14 859
Fugitive Emissions	3 837	3 386	4 455	4 817	4 976	5 139
Product use	1 358	1 762	1 146	1 229	1 286	1 326
Fluorinated gases	64	11 465	10 086	8 267	6 152	4 037
Total	287 656	439 070	335 809	331 734	315 710	310 632

Source: Ministry for Ecological Transition, 2019

The table below shows the GHG emissions corresponding to the Baseline scenario of the INECP.

Table A.8. Total emissions projection in the Target scenario

Emissions projection in the Target scenario (Units: thousand tonnes of CO_2 equivalent)						
Year	**1990**	**2005**	**2015**	**2020**	**2025**	**2030**
Transport	59 199	102 310	83 197	85 722	74 638	57 695
Electricity generation	65 864	112 623	74 051	63 518	27 203	19 650
Industrial sector (combustion processes)	45 099	68 598	40 462	40 499	37 246	33 530
Industrial sector (emissions from processes)	28 559	31 992	21 036	21 509	22 026	22 429
Residential, commercial and institutional sectors	17 571	31 124	28 135	26 558	23 300	19 432
Livestock farming	21 885	25 726	22 854	23 247	21 216	19 184
Crops	12 275	10 868	11 679	11 382	11 086	10 791
Waste	9 825	13 389	14 375	13 657	11 898	9 650
Refining industry	10 878	13 078	11 560	12 247	11 607	10 968
Other energy industries	2 161	1 020	782	721	568	543
Other sectors	9 082	11 729	11 991	14 169	13 701	13 259
Fugitive emissions	3 837	3 386	4 455	4 715	4 419	4 254
Product use	1 358	1 762	1 146	1 231	1 283	1 316
Fluorinated gases	64	11 465	10 086	8 267	6 152	4 037
Total	287 656	439 070	335 809	327 443	266 343	226 737

Source: Ministry for Ecological Transition, 2019

In addition, the emissions are shown disaggregated between those subject to the emission trading system and those that are excluded (diffuse emissions). The tables below outline the disaggregated results for the Target scenario.

Table A.9. Emissions projection in emissions trading systems sectors

Emissions projection in the Target scenario in emissions trading systems sectors (thousand tonnes of CO_2 equivalent)					
Year	**2005**	**2015**	**2020**	**2025**	**2030**
Transport	4 013	2 481	2 566	2 622	2 508
Electricity generation	100 042	69 465	59 669	24 441	17 053
Industrial sector (combustion processes)	56 007	35 073	35 517	32 621	29 316
Industrial sector (emissions from processes)	29 005	18 066	18 402	18 891	19 268
Residential, commercial and institutional sectors	51	156	183	196	186
Livestock farming	0	0	0	0	0
Crops	0	0	0	0	0
Waste	0	0	0	0	0
Refining industry	12 948	11 444	12 124	11 491	10 858
Other energy industries	622	477	440	346	331
Other sectors	0	0	0	0	0
Fugitive emissions	1 514	2 590	2 813	2 666	2 519
Product use	0	0	0	0	0
Fluorinated gases	0	0	0	0	0
ETS Total	204 201	139 751	131 714	93 275	82 039

Source: Ministry for Ecological Transition, 2019

Table A.10. Emissions projection in the diffuse sectors

Emissions projection in the Target scenario in diffuse sectors (thousand tonnes of CO_2 equivalent)					
Year	**2005**	**2015**	**2020**	**2025**	**2030**
Transport	98 297	80 716	83 157	72 016	55 187
Electricity generation	12 582	4 586	3 849	2 762	2 597
Industrial sector (combustion processes)	12 591	5 390	4 982	4 625	4 213
Industrial sector (emissions from processes)	2 988	2 970	3 107	3 135	3 161
Residential, commercial and institutional sectors	31 073	27 980	26 375	23 104	19 247
Livestock farming	25 726	22 854	23 247	21 216	19 184
Crops	10 868	11 679	11 382	11 086	10 791
Waste	13 389	14 375	13 657	11 898	9 650
Refining industry	131	116	122	116	110
Other energy industries	398	305	281	221	212
Other sectors	11 729	11 991	14 169	13 701	13 259
Fugitive emissions	1 872	1 865	1 903	1 753	1 734
Product use	1 762	1 146	1 231	1 283	1 316
Fluorinated gases	11 465	10 086	8 267	6 152	4 037
Total	**234 869**	**196 058**	**195 729**	**173 068**	**144 698**

Source: Ministry for Ecological Transition, 2019

As can be seen in the tables above, the main reductions of GHG emissions take place in the electricity generation and transport sectors. The residential, commercial and institutional sector also makes an important contribution to meeting the emissions reduction target. The only sectors in which emissions increase are the industrial processes sector, other sectors and product use. It should be noted that these sectors have technical difficulties that are difficult to overcome in a cost-efficient manner using current technology.

In conclusion, the target established in this Plan is to reduce GHG emissions by 20 % in 2030 compared to 1990. However, the result of the optimisation made using the TIMES model was 21 %, with a 31 % reduction of GHG emissions between 2020 and 2030.

A.2.2 Renewable energy

Below are the results and projections of the contribution from the generation of energy using renewable energy sources in the final energy consumption.

As stated before, it is important to note that the Plan's key objective is compliance with the mitigation of GHG emissions up to a 20 % reduction compared to 1990.

Contribution of renewables in gross final energy consumption

The total percentage of renewable energy in gross final energy in 2016 was 17.3 %. Regarding the calculation method, the indications established in Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources were followed, as were the amendments introduced in Directive 2018/2001 of the European Parliament and of the Council of 11 December 2018.

Table A.11. Percentage of renewable energy in final energy consumption in the Baseline scenario*

Percentage of renewable energy in final energy consumption in the Baseline scenario					
Years		**2015**	**2020**	**2025**	**2030**
End-use renewable energy consumption (excluding renewable electricity consumption)	Agriculture (ktoe)	4 310	94	96	98
	Industry (ktoe)		1 630	1 646	1 683
	Residential (ktoe)		2 215	2 007	1 807
	Services & Other (ktoe)		210	220	240
	Transport (ktoe)	176	2 307	2 137	2 151
Energy supplied by heat pumps (ktoe)		353	516	516	2 578
Renewable electricity generation (ktoe)		8 642	9 835	9 833	11 887
Total renewable energy (ktoe)		13 481	16 807	16 804	20 572
Final energy corrected with the electricity system losses, aviation consumption and energy supplied by heat pumps (ktoe)		83 361	90 423	90 405	94 064
Percentage of renewable energy in final energy consumption		**16 %**	**19 %**	**22 %**	**25 %**

** The 2015 data are real; the rest are projections prepared by the authors*

Source: Ministry for Ecological Transition, 2019

Table A.12. Percentage of renewable energy in final energy consumption in the Target scenario*

Percentage of renewable energy in final energy consumption in the Target scenario					
Years		**2015**	**2020**	**2025**	**2030**
End-use renewable energy consumption (excluding renewable electricity consumption)	Agriculture (ktoe)	4 310	94	187	278
	Industry (ktoe)		1 721	2 142	2 585
	Residential (ktoe)		2 607	2 932	3 123
	Services & Other (ktoe)		355	481	596
	Transport (ktoe)	176	2 283	2 006	1 568
Energy supplied by heat pumps (ktoe)		353	651	2 943	4 076
Renewable electricity generation (ktoe)		8 642	9 793	15 778	20 988
Total renewable energy (ktoe)		13 481	17 504	26 469	33 216
Final energy corrected with the electricity system losses, aviation consumption and energy supplied by heat pumps (ktoe)		83 361	87 576	85 453	79 413
Percentage of renewable energy in final energy consumption		**16 %**	**20 %**	**31 %**	**42 %**

** The 2015 data are real; the rest are projections prepared by the authors*

Source: Ministry for Ecological Transition, 2019

In the table above, it is seen that in the Target scenario, the percentage of renewable energy in the gross final energy consumption totals 42 % in 2030, while it would total 25 % in the Baseline scenario. In other words, as a result of implementing the measures set out in this Plan, there is a 17-point increase in the presence of renewable energy in the final energy consumption.

The main reasons for this increase are outlined below:

- **In the Baseline scenario**, the only components that increase the abovementioned percentage are the increase in renewable electricity generation and the increased contribution from heat pumps.

- **In the Target scenario:**
  - The contribution from renewable electricity generation doubles, thanks to the policies of increasing the installed renewable system.
  - The contribution from heat pumps increases by 14 % with respect to the Baseline scenario.
  - Unlike the Baseline scenario, in the Target scenario there are increases in the use of final renewable energy in all sectors, i.e. agriculture, industry, residential and services.
  - According to the table above, seemingly, the only sector where the use of end-use renewable energy decreases is transport. In reality, this is due to the fact that the figure shown does not include the electricity contribution in this sector, which is included under the electricity generation heading. Therefore, the high penetration of electrically-propelled vehicles is not directly reflected in this table, but is instead included within renewable electricity generation.
  - The gains in energy saving and efficiency increase the contribution from renewable energy in percentage terms.

The tables below show the sectoral disaggregation of renewable energy.

Renewable energy in heating and cooling applications

Heating and cooling applications include the following sectors: residential, service and industrial. The table below shows the results from this contribution.

Table A.13. Percentage of renewable energy in heating and cooling*

Percentage of renewable energy in heating and cooling applications				
Years	**2015**	**2020**	**2025**	**2030**
Baseline scenario	15 %	15 %	20 %	22 %
Target scenario	15 %	18 %	28 %	34 %

** The 2015 data are real; the rest are projections prepared by the authors*

Source: Ministry for Ecological Transition, 2019

In the results from the table above, and in a manner consistent with the development of the global percentage, the Target scenario shows a higher percentage of renewable energy in heating and cooling. The main conclusions in this regard are presented below:

- The promotion of the use of end-use renewable energy, such as biomass, biogas and solar thermal energy, has a significant impact on the increase in this percentage.
- The increased use of heat pumps for air conditioning also has a significant impact. This effect is especially noted in the Target scenario, since it is more economically viable to introduce heat pumps in dwellings.

Transport

Table A.14. Percentage of renewable energy in the transport sector*

Percentage of renewable energy in transport				
Years	**2015**	**2020**	**2025**	**2030**
Baseline scenario	1 %	10 %	9 %	11 %
Target scenario	1 %	10 %	12 %	22 %

** The 2015 data are real; the rest are projections prepared by the authors*

Source: Ministry for Ecological Transition, 2019

As can be observed in the table above, the compulsory national target of 14 % for presence of renewable energy in transport for 2030, established in Directive 2018/2001 on the promotion of the use of energy from renewable sources, is met comfortably.

On the other hand, it is important to confirm that compliance with the 2020 target of 10 % renewable energy in transport is verified in both the Baseline scenario and the Target scenario. This is achieved mainly through the use of biofuels.

It should be noted that the percentage of renewable energy in transport corresponding to 2015 is reduced due to the fact that the biofuel sustainability certification procedure was still not approved. For this reason, the consumption of biofuels without sustainability certification could not be included in the calculation of this percentage. This situation is clearly apparent when analysing the information available on actual biofuel consumption for 2016, the figure for which is 5.28 %.

The main differences between both scenarios are analysed next, resulting in a very significant increase in the presence of renewable energy in transport:

- **Accelerated introduction of electrified vehicles in the Target scenario.** In 2030, there will be over 3.5 million electric passenger cars and over one million motorcycles, light trucks and buses in the vehicle fleet. These vehicles will total 5 million units. The introduction of electric mobility is gradual, going from the current values until it reaches this figure in 2030. It is important to bear in mind that electrified vehicles only count in the percentage of renewable energy in transport in the proportion in which the electricity mix generates electricity using renewable energy sources.
- **Increase in mobility by means of electrified rail transport.** This also has significant importance, provided that, as in the point above, the electricity generation comes from renewable energy sources.
- **Use of advanced biofuels**.

Renewable energy in the electricity sector

This section begins with the results related to the generation of renewable energy in the electricity generation system, which are shown below.

Table A.15. Percentage of renewable energy in the electricity generation sector*

Percentage of renewable energy in electricity generation				
Years	**2015**	**2020**	**2025**	**2030**
Baseline scenario	37 %	41 %	50 %	55 %
Target scenario	37 %	40 %	60 %	74 %

** The 2015 data are real; the rest are projections*

Source: Ministry for Ecological Transition, 2019

There is also a more detailed explanation of the electricity sector, since this is one of the most important components contributing to the decarbonisation of the energy system, as well as to meeting the renewable energy target.

Electricity sector

Firstly, the installed capacity of the different generation technologies is presented in the Baseline scenario.

In the Baseline scenario, the total installed capacity in Spanish territory increases from 113.09 GW in 2020 to 124.49 GW in 2030, representing a 10 % increase during this period (11.40 GW). The main increases come from wind and solar photovoltaic technologies, with around 10 GW each. It should be underlined that 100 % of the nuclear thermal capacity remains in operation at the end of the period, as well as the coal capacity, with respect to the installed capacity in 2020.

Table A.16. Electricity generation system in the Baseline scenario

Generation system in the Baseline scenario (MW)				
Year	**2015**	**2020**	**2025**	**2030**
Wind	22 925	27 968	32 968	37 968
Solar photovoltaic	4 854	8 409	13 404	18 382
Solar thermoelectric	2 300	2 303	2 303	2 303
Hydroelectric power	14 104	14 109	14 109	14 109
Mixed Pumping	2 687	2 687	2 687	2 687
Pure Pumping	3 337	3 337	3 337	3 337
Biogas	223	235	235	235
Biomass	677	877	877	877
Coal	11 311	10 524	4 532	4 532
Combined cycle	27 531	27 146	27 146	27 146
Coal cogeneration	44	44	0	0
Gas cogeneration	4 055	4 001	3 232	1 890
Petroleum products cogeneration	585	570	400	230
Fuel/Gas	2 790	2 790	2 790	2 790
Renewables cogeneration	535	430	372	361
Cogeneration with waste	30	24	18	11
Municipal solid waste	234	234	234	234
Nuclear	7 399	7 400	7 400	7 400
Total	105 621	113 087	116 042	124 492

Source: Ministry for Ecological Transition, 2019

In the Target scenario, total installed capacity increases to 156.96 GW in 2030, representing an increase close to 40 % during this period (43.8 GW), as well as 26 % more than in the same year in the Baseline scenario.

Similar to what was shown in the Baseline scenario, the main increases come from wind and solar photovoltaic technologies, with approximately 22 GW and 28 GW respectively. It must be remembered that although the renewable energy totals are agreed by the INECP, the relative figures from the different technologies are indicative and liable to modification according to technological developments, costs and availability of different technologies. Likewise, these figures include different topologies of existing and future technologies, e.g. including, but not limited to: distributed generation and conventional generation capacity, onshore and offshore wind capacity, large photovoltaic generation plants and small individual installations.

Table A.17. Electricity generation system in the Target scenario

Generation system in the Target Scenario (MW)				
Year	**2015**	**2020**	**2025**	**2030**
Wind	22 925	27 968	40 258	50 258
Solar photovoltaic	4 854	8 409	23 404	36 882
Solar thermoelectric	2 300	2 303	4 803	7 303
Hydroelectric power	14 104	14 109	14 359	14 609
Mixed Pumping	2 687	2 687	2 687	2 687
Pure Pumping	3 337	3 337	4 212	6 837
Biogas	223	235	235	235
Geothermal	0	0	15	30
Marine energy	0	0	25	50
Biomass	677	877	1 077	1 677
Coal	11 311	10 524	4 532	0-1 300
Combined cycle	27 531	27 146	27 146	27 146
Coal cogeneration	44	44	0	0
Gas cogeneration	4 055	4 001	3 373	3 000
Petroleum products cogeneration	585	570	400	230
Fuel/Gas	2 790	2 790	2 441	2 093
Renewables cogeneration	535	491	491	491
Cogeneration with waste	30	28	28	24
Municipal solid waste	234	234	234	234
Nuclear	7 399	7 399	7 399	3 181
Total	105 621	113 151	137 117	156 965

Source: Ministry for Ecological Transition, 2019

Also of note is the rise of hydraulic pumping and solar thermoelectric technologies, with an additional capacity of 3.5 GW and 5 GW, respectively. This capacity, which offers greater power dispatch capability, will be complemented by the staggered introduction of batteries into the system, the aim of which must be to reduce wastage and maximise the production capacity of non-dispatchable renewable technologies. These batteries will have a capacity equivalent to approximately 2.5 GW in 2030, with a maximum of two hours' storage at full charge.

On the other hand, in the period 2021-2030, there is a decrease in the installed capacity of the nuclear power plants greater than 4 GW (capacity corresponding to four reactors of the seven currently in operation). This decrease is part of the organised, phased and flexible closure plan for the existing nuclear reactors, which foresees the closure of another three reactors in the period between 2031 and 2035.

There is also the termination of electricity generation from any coal-fired power plants that may continue to operate beyond 2020 (a maximum of five or six of the 15 currently in existence), by 2030 at the latest. In any case, it cannot be ruled out that part of the installed capacity will be maintained where investments have been made to comply with the EU framework and, for the sake of accounting prudence, this figure is reflected in the table relating to the evolution of installed capacity of electricity from coal.

The main reason for this termination will be the difficulty for coal-fired power plants to continue to be profitable in a setting that is strongly conditioned by the European response to climate change, in which the price of a tonne of CO_2 will be at least EUR 35. At any rate, the termination of electricity generation at coal-fired power plants will be essential for achieving this Plan's key target of mitigating GHG by at least 20 % in 2030 as compared to 1990. In that regard, the very viability of the INECP mitigation targets will depend on that element, and therefore the government will implement in due course the actions it considers necessary to ensure that the electricity sector decarbonisation targets for 2030 are successful.

It should also be noted that there are plans to repower the entire renewable system currently in existence after its service life ends, maintaining the **renewal and hybridisation measures in existing projects** included in the present INECP.

It must be stated that the primary objective of the electricity system is to guarantee the electricity supply to consumers, in optimal conditions of service quality and security. According to the feasibility studies carried out in relation to the proposed generation system, it will not be necessary to install additional backup thermal capacity as a supplement to the generation mix obtained with the TIMES-Sinergia model[54].

In any case, as system operator, REE will at all times seek to ensure the correct operation of the transmission and distribution networks, as well as the guarantee of electricity supply.

Finally, as explained above, the high penetration of renewable capacity in the electricity generation system will be accompanied by the following actions:

- promoting the necessary network infrastructure;
- maximising the use of the available access capacity by means of efficient capacity allocation procedures;
- simplifying the administrative and environmental processing for installation authorisations, so that this processing does not turn into an obstacle for the construction of generation installations and the infrastructure needed to commission them, especially in the case of repowering;
- reviewing the operation of the electricity market, if this is considered necessary, as a mechanism to encourage the maximum use of the country's renewable generation potential.

Having explained the generation system, the results regarding electricity generation are shown below[55]:

Table A.18. Gross electricity generation in the Baseline scenario

Gross electricity generation in the Baseline scenario* (GWh)				
Year	**2015**	**2020**	**2025**	**2030**
Wind	49 325	60 511	75 225	90 991
Solar photovoltaic	13 860	15 132	24 122	33 080
Solar thermoelectric		4 968	4 968	4 968
Hydroelectric power	28 140	28 282	28 282	28 282
Pumping	3 228	4 690	4 690	4 690
Biogas/Geothermal/Marine energy	982	447	482	897
Coal	122 415	47 361	28 981	23 820
Combined cycle		23 108	22 129	31 243
Coal cogeneration		76	0	0
Gas cogeneration		24 054	20 314	12 023
Petroleum products cogeneration		2 065	1 425	697
Fuel/Gas		4 367	4 367	4 367
Renewables cogeneration	5 766	862	873	1 133
Biomass		3 991	4 105	4 714
Cogeneration with waste		96	71	46
Municipal solid waste		1 575	1 575	1 575
Nuclear	57 305	57 693	57 693	57 693
General total	281 021	279 281	279 301	300 219

* Generation from hydroelectric power, pure pumping and mixed pumping technologies is included in pumping and hydroelectric power generation

54 As can be confirmed in the annex corresponding to the modelling, the electricity generation system resulting from the TIMES-Sinergia model has been analysed by Red Eléctrica de España.

55 The generation values corresponding to 2015 are based on the values reported to Eurostat for that year, having made the necessary estimations according to the breakdown presented.

Source: Ministry for Ecological Transition, 2019

Table A.19. Baseline scenario electricity mix

Baseline scenario electricity mix (GWh)				
Year	**2015**	**2020**	**2025**	**2030**
Gross electricity generation	276 754	279 281	279 301	300 219
Consumption in generation	-11 626	-11 254	-10 140	-10 238
Net electricity generation	265 128	268 027	269 161	289 982
Consumption in pumping	-6 354	-6 354	-6 354	-6 354
Export	-15 074	-9 251	-12 600	-26 839
Import	14 847	18 111	23 846	22 415
Demand in power plant busbars[56]	258 547	270 533	274 053	279 204
Consumption in energy transformation sector	-6 967	-7 265	-7 311	-7 521
Transmission and distribution losses	-24 264	-25 157	-25 359	-25 819
Final electricity demand from non-energy sectors	227 315	238 111	241 382	245 864

Source: Ministry for Ecological Transition, 2019

Main conclusions related to the Baseline scenario:

- The final electricity demand in Spain increases by 3.3 % during the period covered, going from 238 TWh in 2020 to 246 TWh in 2030.
- The net balance at the border is import for the year 2020, amounting to 8.86 TWh, turning into export in the year 2030, amounting to 4.42 TWh.
- The percentage of renewable generation in the electricity sector for 2020 stands at 41 %, increasing to 55 % in 2030, i.e. 14 percentage points of difference.

Table A.20. Gross electricity generation in the Target scenario

<table>
<tr><th colspan="5">Gross electricity generation in the Target scenario* (GWh)</th></tr>
<tr><th>Year</th><th>2015</th><th>2020</th><th>2025</th><th>2030</th></tr>
<tr><td>Wind</td><td>49 325</td><td>60 521</td><td>92 053</td><td>116 110</td></tr>
<tr><td>Solar photovoltaic</td><td rowspan="2">13 860</td><td>15 132</td><td>42 118</td><td>66 373</td></tr>
<tr><td>Solar thermoelectric</td><td>4 968</td><td>13 953</td><td>22 578</td></tr>
<tr><td>Hydroelectric power</td><td>28 140</td><td>28 282</td><td>28 663</td><td>29 045</td></tr>
<tr><td>Pumping</td><td>3 228</td><td>4 690</td><td>5 610</td><td>8 369</td></tr>
<tr><td>Biogas</td><td rowspan="3">982</td><td>447</td><td>482</td><td>897</td></tr>
<tr><td>Geothermal energy</td><td>0</td><td>94</td><td>188</td></tr>
<tr><td>Marine energy</td><td>0</td><td>59</td><td>74</td></tr>
<tr><td>Coal</td><td rowspan="6">122 415</td><td>47 195</td><td>15 094</td><td>0</td></tr>
<tr><td>Combined cycle</td><td>32 800</td><td>15 304</td><td>34 922</td></tr>
<tr><td>Coal cogeneration</td><td>76</td><td>0</td><td>0</td></tr>
<tr><td>Gas cogeneration</td><td>24 054</td><td>20 603</td><td>15 566</td></tr>
<tr><td>Petroleum products cogeneration</td><td>2 065</td><td>1 425</td><td>697</td></tr>
<tr><td>Fuel/Gas</td><td>5 372</td><td>4 700</td><td>4 029</td></tr>
<tr><td>Renewables cogeneration</td><td rowspan="4">5 766</td><td>862</td><td>1 192</td><td>1 556</td></tr>
<tr><td>Biomass</td><td>3 991</td><td>5 605</td><td>10 714</td></tr>
<tr><td>Cogeneration with waste</td><td>96</td><td>93</td><td>84</td></tr>
<tr><td>Municipal solid waste</td><td>605</td><td>783</td><td>1 447</td></tr>
<tr><td>Nuclear</td><td>57 305</td><td>57 686</td><td>57 686</td><td>24 800</td></tr>
<tr><td>Total</td><td>281 021</td><td>288 843</td><td>305 518</td><td>337 448</td></tr>
</table>

* Generation from hydroelectric power, pure pumping and mixed pumping technologies are included in pumping and hydroelectric power generation

[56] Demand in power plant busbars defined as energy injected into the network from generation centres and imports, deducting consumption in pumping and exports.

Source: Ministry for Ecological Transition, 2019

Table A.21. Target scenario electricity mix

Target scenario electricity mix (GWh)				
Year	**2015**	**2020**	**2025**	**2030**
Gross electricity generation	281 021	288 843	305 518	337 448
Consumption in generation	-11 270	-11 229	-10 255	-10 143
Net electricity generation	269 751	277 614	295 264	327 305
Consumption in pumping	-4 520	-6 354	-7 548	-11 132
Export	-15 089	-12 951	-28 351	-39 987
Import	14 956	9 055	12 638	8 225
Demand in power plant busbars	265 098	267 365	272 003	284 412
Consumption in energy transformation sector	-6 501	-7 070	-6 545	-6 195
Transmission and distribution losses	-26 509	-24 852	-24 994	-25 622
Final electricity demand from non-energy sectors	232 088	235 443	240 463	252 594

Source: Ministry for Ecological Transition, 2019

Main conclusions related to the Target scenario:

- The final electricity demand increases from 235.4 TWh in 2020 to 252.6 TWh in 2030, rising by 7.3 %.
- The net balance at the border is clearly export in 2030, totalling 31.7 TWh. This balance is driven by the high penetration of renewable capacity in the system.
- The percentage of renewable generation in the electricity sector experiences a 34-percentage-point increase during this period, going from 39.7 % in 2020 to 73.6 % in 2030.

Thus, looking at both scenarios together, Baseline and Target, for 2030, it is important to highlight the main differences:

- Total installed capacity of 124.49 GW compared to 156.96 GW, i.e. 32 GW more installed capacity in the Target scenario compared to the Baseline.
- Net increase of renewable capacity of 57 GW in the Target scenario compared to the 20 GW in the Baseline scenario.
- Organised, phased and flexible closure of nuclear installations, affecting four reactors during the Plan's validity period. Moreover, the termination of electricity generation by coal-fired power plants. On the other hand, the service life of all nuclear installations is extended in the Baseline scenario and it is assumed that coal-fired power plants are fully operational in electricity generation.
- Higher final electricity demand in the Target scenario, amounting to 6.7 TWh (2.7 % increase compared to the Baseline).
- Higher percentage of renewable generation in the electricity sector in the Target scenario: 73.6 %, equivalent to 18.7 percentage points above what would be achieved in the Baseline scenario.
- The net balance at the border strengthens its exporting role in the Target scenario, exporting an additional 27 TWh in net value compared to the Baseline scenario.

A.3 DIMENSION ENERGY EFFICIENCY

This chapter refers to the effects of the energy efficiency policies and measures of the different sectors of the economy. It has been mentioned before that the main objective of the Plan is to reduce GHG emissions, while two main directions can be distinguished within the proposed measures to do this:

- The replacement of fossil fuels with other energy sources that are less polluting or more energy efficient.
- Reducing energy consumption to satisfy the same demands or, in other words, increasing energy efficiency, which is the subject of this section.

A.3.1 Primary energy consumption

The tables below set out the aggregate primary energy for all sectors both for the Baseline scenario and for the Target scenario.

Table A.22. Primary energy consumption including non-energy uses in the Baseline scenario

Primary energy consumption including non-energy uses in the Baseline scenario (ktoe)				
Year	2015	2020	2025	2030
Coal	13 714	11 440	7 607	6 552
Oil and its derivatives	52 949	51 860	52 366	52 195
Natural gas	24 538	27 013	28 236	29 861
Nuclear energy	14 927	15 033	15 033	15 033
Renewables	16 646	20 833	22 499	25 050
Industrial waste		282	292	301
MSW (non-renewable)	252	322	295	209
Electricity	-11	762	967	380
Total	123 015	127 545	127 295	128 820

Source: Ministry for Ecological Transition, 2019

Table A.23. Primary energy consumption including non-energy uses in the Target scenario

Primary energy consumption including non-energy uses in the Target scenario (ktoe)				
Year	2015	2020	2025	2030
Coal	13 714	11 337	4 362	1 128
Oil and its derivatives	52 949	50 999	45 453	38 149
Natural gas	24 538	26 498	23 501	24 531
Nuclear energy	14 927	15 031	15 031	6 462
Renewables	16 646	20 856	28 093	35 066
Industrial waste		238	282	341
MSW (non-renewable)	252	105	123	190
Electricity	-11	-335	-1 351	-2 731
Total	123 015	124 727	115 494	103 136

Source: Ministry for Ecological Transition, 2019

These are the main conclusions with regard to the tables above:

- The consumption of petroleum products and natural gas in **2015** exceeds 60 % of the total. The policies and measures included in the Plan are geared towards reducing this dependency on hydrocarbons in the country's energy mix.
- **In the Baseline scenario**, energy consumption in 2030 increases by approximately 5 % starting from 2015.
- **In the Target scenario:**

- The impact of the policies and measures to decarbonise the economy is clearly reflected, as well as the significant introduction of renewables in the primary energy mix. Primary energy consumption in 2030 decreases by 16 % compared to 2015. This contrasts with a 6 % increase registered in the Baseline scenario for the same period.
- Consumption from renewables doubles in 2030 compared to 2015.
- Coal consumption decreases to practically one-tenth of the 2015 consumption, due mainly to the gradual closure of coal-fired power plants.
- Petroleum product consumption drops by 28 % compared to 2015, while natural gas remains very similar.
- Nuclear consumption is decreasing, accompanying the scheduled, phased and organised closure of power plants.

A.3.2 Final energy consumption

The total final energy consumption projections for each of the sectors included in the model are shown below: industry, residential, service and transport.

Table A.24. Final energy consumption including non-energy uses in the Baseline scenario

Final energy consumption including non-energy uses in the Baseline scenario (ktoe)				
Year	2015	2020	2025	2030
Coal	1 522	1 337	1 395	1 427
Petroleum products	40 330	40 747	40 910	40 452
Natural gas	13 139	18 184	19 985	21 060
Electricity	19 951	20 332	20 612	20 996
Renewable energy	5 287	6 470	6 122	5 994
Other non-renewables	2	306	310	312
Non-energy	4 311	4 405	4 681	4 894
Total	84 542	91 781	94 017	95 136

Source: Ministry for Ecological Transition, 2019

Table A.25. Final energy consumption including non-energy uses in the Target scenario

Final energy consumption including non-energy uses in the Target scenario (ktoe)				
Year	2015	2020	2021	2022
Coal	1 522	1 239	1 090	1 040
Petroleum products	40 330	39 690	34 528	27 653
Natural gas	13 139	16 218	16 701	15 677
Electricity	19 951	20 105	20 537	21 579
Renewable energy	5 287	7 073	7 702	8 073
Other non-renewables	2	263	306	362
Non-energy	4 311	4 405	4 681	4 894
Total	84 542	88 994	85 544	79 279

Source: Ministry for Ecological Transition, 2019

The following are the main comments on final energy consumption:

- The main difference between the Baseline and Target scenarios is that final energy consumption increases in the former and decreases in the latter. The Target scenario shows a very significant decrease, around 30 %, in petroleum product consumption. Owing to all the proposed measures, the Spanish economy will be much more efficient in 2030 and much less dependent on oil.
- Regarding the Target scenario:
  - Final energy consumption decreases around 6 %, despite the fact that the economic growth path is always growing. This means that, with the proposed

measures, progress will be made in decoupling economic growth and energy consumption.
- Electricity consumption increases by around 8 %.
- Final petroleum product consumption decreases around 30 % compared to the actual 2015 data. However, natural gas consumption increases by around 19 %.
- Renewable energy consumption increases by around 50 %.

In conclusion, the needs of the Spanish economy in 2030 will be satisfied in a more efficient manner in energy terms.

Industrial Sector

The following tables set out final energy consumption in the industrial sector.

Table A.26. Final energy consumption in the industrial sector (excluding non-energy uses) for the Baseline scenario

Final energy consumption in the industrial sector (excluding non-energy uses) for the Baseline scenario (ktoe)				
Year	**2015**	**2020**	**2025**	**2030**
Coal	1 158	1 292	1 357	1 389
Petroleum products	2 742	2 262	2 439	2 866
Natural gas	6 895	9 962	10 264	10 117
Electricity	6 540	6 898	7 306	7 628
Renewable energy	1 344	1 644	1 660	1 697
Other non-renewables	0	306	310	312
Total	18 678	22 363	23 338	24 009

Source: Ministry for Ecological Transition, 2019

Table A.27. Final energy consumption in the industrial sector (excluding non-energy uses) for the Target scenario

Final energy consumption in the industrial sector (excluding non-energy uses) for the Target scenario (ktoe)				
Year	**2015**	**2020**	**2025**	**2030**
Coal	1 158	1 217	1 082	1 040
Petroleum products	2 742	2 057	1 662	1 417
Natural gas	6 895	9 748	9 786	9 262
Electricity	6 540	6 821	7 017	7 363
Renewable energy	1 344	1 735	2 095	2 507
Other non-renewables	0	263	306	362
Total	18 678	21 840	21 948	21 952

Source: Ministry for Ecological Transition, 2019

As regards industry in the Target scenario, the following can be highlighted:

- Decrease in final energy consumption compared to the Baseline scenario, brought about by energy efficiency policies and measures.
- This decrease in final consumption translates directly into coal and petroleum products, thus contributing to reducing the industrial sector's GHG emissions.

Residential

The following tables set out final energy consumption in the residential sector.

Table A.28. Final energy consumption in the residential sector (excluding non-energy uses) for the Baseline scenario

Final energy consumption in the residential sector (excluding non-energy uses) for the Baseline scenario (ktoe)				
Year	**2015**	**2020**	**2025**	**2030**
Coal	89	8	0	0
Petroleum products	3 031	2 308	1 512	613
Natural gas	3 022	3 589	4 256	5 057
Electricity	6 025	5 952	5 830	5 695
Renewable energy	2 832	2 216	2 008	1 808
General total	14 998	14 073	13 606	13 172

Source: Ministry for Ecological Transition, 2019

Table A.29. Final energy consumption in the residential sector (excluding non-energy uses) for the Target scenario

Final energy consumption in the residential sector (excluding non-energy uses) for the Target scenario (ktoe)				
Year	**2015**	**2020**	**2025**	**2030**
Coal	89	8	0	0
Petroleum products	3 031	2 247	1 184	550
Natural gas	3 022	2 983	3 024	2 737
Electricity	6 025	5 656	5 477	5 301
Renewable energy	2 832	2 607	2 932	3 123
General total	14 998	13 501	12 617	11 710

Source: Ministry for Ecological Transition, 2019

The main conclusion drawn from the residential sector is an increase in efficiency, which, together with an increase in renewable energy and a significant decrease in natural gas consumption, enable this sector to reduce its GHG emissions at a much faster speed than in the Baseline scenario thanks to the measures proposed in the Plan.

Services and other

The following tables set out final energy consumption in the services and other sector.

Table A.30. Final energy consumption in the services and other sector (excluding non-energy uses) for the Baseline scenario

Final energy consumption in the services and other sector (excluding non-energy uses) for the Baseline scenario (ktoe)				
Year	**2015**	**2020**	**2025**	**2030**
Coal	29	37	38	38
Petroleum products	1 118	969	689	458
Natural gas	2 819	3 180	3 689	3 712
Electricity	6 406	6 505	6 446	6 551
Renewable energy	337	210	221	240
Total	10 710	10 901	11 082	10 999

Source: Ministry for Ecological Transition, 2019

Table A.31. Final energy consumption in the services and other sector (excluding non-energy uses) for the Target scenario

Final energy consumption in the services and other sector (excluding non-energy uses) for the Target scenario (Units: ktoe)				
Year	**2015**	**2020**	**2025**	**2030**
Coal	29	14	7	0
Petroleum products	1 118	857	575	325
Natural gas	2 819	2 899	3 089	2 911
Electricity	6 406	6 618	6 461	6 467
Renewable energy	337	355	481	596
Total	10 710	10 743	10 613	10 300

Source: Ministry for Ecological Transition, 2019

The main conclusions drawn from the services and other sector are the increase in efficiency, as well as increased electrification and increased consumption of renewable energy. This all results in the reduction of petroleum product and natural gas consumption in the Target scenario compared to the Baseline scenario.

Transport

The following tables set out final energy consumption in the transport sector.

Table A.32. Final energy consumption in the transport sector (excluding non-energy uses) for the Baseline scenario

Final energy consumption in the transport sector (excluding non-energy uses) for the Baseline scenario (ktoe)				
Year	**2015**	**2020**	**2025**	**2030**
Petroleum products	27 979	33 048	34 053	34 256
Natural gas	328	1 371	1 693	2 089
Electricity	480	391	427	509
Renewable energy	756	2 307	2 137	2 151
Total	29 542	37 117	38 311	39 005

Source: Ministry for Ecological Transition, 2019

Table A.33. Final energy consumption in the transport sector (excluding non-energy uses) for the Target scenario

Final energy consumption in the transport sector (excluding non-energy uses) for the Target scenario (ktoe)				
Year	**2015**	**2020**	**2025**	**2030**
Petroleum products	27 979	32 369	29 030	23 362
Natural gas	328	508	720	684
Electricity	480	423	953	1 776
Renewable energy	756	2 283	2 006	1 568
Total	29 542	35 583	32 709	27 390

Source: Ministry for Ecological Transition, 2019

The main conclusions that affect final energy consumption in the transport sector are presented:

- Firstly, there is a sharp decrease in final energy consumption brought about by the measures to increase efficiency in the use of vehicles, the introduction of new, more efficient vehicles and modal shift policies.
- Moreover, there is a very significant decrease in the consumption of petroleum products, which are replaced with electricity.
- Finally, both gas and biofuel consumption are lower in the Target scenario than in the Baseline. This is due to the fact that the final consumption of the whole sector is

considerably lower, and therefore compliance with the decarbonisation targets is achieved by using electrified vehicles, as well as through the decrease in the demand for fossil fuel vehicles due to the different modal shifts proposed.

A.3.3 Energy intensity

The following table shows the energy intensity values for primary energy as well as final energy for both scenarios.

It can be seen that in the Baseline scenario, there is already an improvement in energy intensities. In other words, the energy system is becoming more efficient in this 'status quo' scenario. Nevertheless, the efficiency and GHG emission reduction policies have a prominent effect in the Target scenario. Energy intensity values are achieved in this scenario that entail a decrease of approximately 30 % compared to the 2017 values. The energy intensity in 2017 was 115 toe/EUR m in primary energy, and 79 toe/EUR m in final energy.

Table A.34. Energy intensities for primary and final energy in the Baseline and Target scenarios

Energy intensities for primary and final energy in the Baseline and Target scenarios (toe/€ m base year 2016)					
Year		2015	2020	2025	2030
Baseline scenario	Primary energy intensity	115	104	95	91
	Final energy intensity	79	75	70	67
Target scenario	Primary energy intensity	115	102	87	73
	Final energy intensity	79	73	64	56

Source: Ministry for Ecological Transition, 2019

A.4 DIMENSION ENERGY SECURITY

This section analyses the effects of the country's primary energy mix on security of energy supply. The consumption of hydrocarbons (oil and natural gas) in primary energy accounts for approximately 60 % of the total at present. For this reason, and considering that indigenous hydrocarbon production is residual, the supply of these types of fuels is fundamental for the country's energy security, defined as security of supply.

To reduce the exposure to risks that could represent a decrease in the supply of these fuels, two routes have been followed that are complementary to the other targets in this Plan:

- Firstly, an increase in the country's energy efficiency will reduce the total energy demand, and therefore less energy will be needed to meet this demand.
- Secondly, and to increase the effect of the above, in the Target scenario there is significant replacement of fossil fuels with other indigenous fuels (almost entirely renewables).

It has been possible to see these two effects in the sections above that have explained the Spanish economy's primary and final energy consumption.

On the other hand, this section also analyses the external dependency of the electricity generation sector. This sector is also dependent on hydrocarbon consumption, although to a lesser extent than the rest of the economy.

A.4.1 Current energy mix, domestic energy resources, import dependency

The sections above have presented the different primary energy sources that form the origin of the energy supply to Spain, as well as the breakdown and future projection. The following observations can be made regarding security of supply based on these sources:

- The presence of natural gas in the Spanish energy mix is slightly lower than that of other EU Member States, which can be explained, inter alia, by the following reasons:
    - a milder climate, resulting in lower penetration of natural gas between domestic consumers and central heating;
    - greater significance of natural gas in the generation of electricity, which means that its presence in final energy is clearly lower than the share in primary energy.
- As for petroleum products, their presence in the national energy mix is much higher than the EU average. This can be explained by the following reasons:
    - a high development of freight transport by road at the expense of rail transport (2 % on average in Spain, compared to 17 % in the EU);
    - significant consumption for maritime transport compared to inland Member States;
    - significant consumption for air transport due to the importance of the tourism sector.

With reference to the national production of hydrocarbons, it should be noted that this is practically non-existent. Data for 2017 are as follows:

- **Domestic natural gas production (2017):** 400 GWh (0.11 % of total requirements). Domestic production is considered to be not only production from hydrocarbon deposits, but also the injection of biogas into the transmission network.
- **Domestic crude production (2017):** 0.12 tonnes (0.21 % of requirements).

The main countries of origin for the different energy sources are the following:

- **Electricity:** Spain has electricity interconnections with France, Portugal, Andorra and Morocco. Details of the imports and exports with these countries can be found in the table below.

Table A.35. Monthly physical international exchanges by border*

Monthly physical international exchanges by border (GWh)				
Year		**2010**	**2015**	**2017**
Inputs	Andorra	0	0	0
	France	1 983	9 131	15 564
	Portugal	3 189	5 811	8 190
	Morocco	34	14	8
	Total	5 206	14 956	23 763
Outputs	Andorra	264	264	233
	France	3 514	1 807	3 099
	Portugal	5 823	8 077	5 505
	Morocco	3 937	4 941	5 756
	Total	13 539	15 089	14 594
Balance (1)	Andorra	-264	-264	-233
	France	-1 531	7 324	12 465
	Portugal	-2 634	-2 266	2 685
	Morocco	-3 903	-4 927	-5 748
	Total	**-8 333**	**-133**	**9 169**

**Positive value: import balance; Negative value: export balance.*

Source: Red Eléctrica de España

- **Natural gas:** in 2017, 60 % of imports were made through gas pipelines, compared to 40 % in methane tankers in the form of liquefied natural gas (LNG) through regasification plants.
  The breakdown by country of origin of natural gas imports in 2017 was as follows:
  - Algeria (48 %)
  - Nigeria (12 %)
  - Peru (10 %)
  - Qatar (10 %)
  - Norway (10 %)
  - Others (10 %)

In light of the above, the relative dependence on the importation of natural gas from Algeria can be highlighted as a possible risk, which is offset by the high level of imports by methane tankers from a wide range of countries of origin.

- **Petroleum products:** the main countries of origin of crude oil in 2017 were the following: As can be seen, the diversification in the sources of oil origin is much higher than the diversification for gas.
  - Mexico (15 %)
  - Nigeria (14 %)
  - Saudi Arabia (10 %)

A.4.2 Projections of development for the energy mix, domestic energy resources, import dependency with the existing policies and measures

The projection to 2030 is presented below for the breakdown of primary energy according to indigenous production and imports for the Baseline and Target scenarios.

Tabla A.36 Origin of the primary energy, Baseline scenario

Origin of the primary energy, Baseline scenario (ktoe)				
Year	**2015**	**2020**	**2025**	**2030**
National production	**33 615 (27 %)**	**37 004 (29 %)**	**37 626 (30 %)**	**40 458 (31 %)**
Coal	1 246	1 145	0	0
Petroleum products	236	310	312	314
Natural gas	54	24	24	24
Nuclear	14 927	15 033	15 033	15 033
Renewable energy	16 899	19 567	21 376	24 369
Waste	252	926	881	719
Net imported/exported	**89 400 (73 %)**	**90 541 (71 %)**	**89 669 (70 %)**	**88 361 (69 %)**
Coal	12 468	10 295	7 607	6 552
Petroleum products	52 713	51 550	52 054	51 880
Natural gas	24 484	26 989	28 212	29 837
Electricity	-11	762	967	380
Renewable energy	-253	944	829	472
Total Primary Energy	**123 015**	**127 545**	**127 295**	**128 820**

Source: Ministry for Ecological Transition, 2019

Tabla A.37 Evolution of the primary energy dependency ratio (ktoe)

Origin of the primary energy, Target scenario (ktoe)				
Years	**2015**	**2020**	**2025**	**2030**
National production	**33 615 (27 %)**	**36 719 (29 %)**	**42 892 (37 %)**	**41 823 (41 %)**
Coal	1 246	1 110	0	0
Petroleum products	236	310	312	314
Natural gas	54	24	24	24
Nuclear	14 927	15 031	15 031	6 462
Renewable energy	16 899	19 797	26 998	34 301
Waste	252	448	528	721
Net imported/exported	**89 400 (73 %)**	**88 008 (71 %)**	**72 602 (63 %)**	**61 313 (59 %)**
Coal	12 468	10 227	4 362	1 128
Petroleum products	52 713	50 688	45 141	37 835
Natural gas	24 484	26 474	23 478	24 507
Electricity	-11	-335	-1 351	-2 731
Renewable energy	-253	954	973	575
Total Primary Energy	**123 015**	**124 727**	**115 494**	**103 136**

Source: Ministry for Ecological Transition, 2019

With regard to the situation in 2017, where there is a dependency ratio for imports of 74 %, the Target scenario represents a substantial reduction, around 15 %, thus coming down from the barrier of 60 % external energy dependency. One of the national energy system's structural weaknesses begins to decrease with this achievement.

In addition, the importation of fossil fuels decreases in an even greater percentage than the energy dependency. This effect is achieved due to the combination of the two effects mentioned at the beginning of this section: the reduction of the global energy consumption through the use of energy efficiency, as well as the replacement of the use of hydrocarbons with indigenous fuels (especially renewables and largely thanks to an increased electrification of the sectors).

With all of the above, a very substantial improvement is projected on the 2030 horizon for the trade balance, provided that the policies and measures included in the Plan are complied with. Specifically, there is a shift from a net importation of 95 945 ktoe between coal, natural gas and oil in 2017 to 63 470 ktoe in 2030 (a 34 % reduction).

With regard to electricity, the increase in the installed capacity from renewable energy sources increases security of the supply due to the use of indigenous sources and the increase in the diversification of sources. The Target scenario achieves a figure of 74 % of electricity generated using renewable energy sources. In terms of its relationship with security of the supply, note should be taken of the increase in interconnections with France that is planned to progressively move towards the targets set by the EU of an interconnection capacity of at least 15 % of the installed capacity of each Member State. This point is analysed in greater detail in the next chapter.

A.5 INTERNAL ENERGY MARKET

This dimension analyses the various components that make up the internal energy market. Interconnectivity, energy transmission infrastructure and the integration of the energy market are highlighted due to their importance.

The two markets referred to in this section are electricity and gas. The international exchanges in the electricity market take place via interconnections between countries. International exchanges of gas, on the other hand, can take place via gas pipelines or using tankers that transport liquefied natural gas.

These international exchanges are fundamental for progressing towards a unified European energy market.

A.5.1 Interconnectivity

A.5.1.1 Electricity system interconnectivity

Current interconnection level and main interconnections

Spain is currently electrically interconnected with the Member States Portugal and France, as well as with Andorra and Morocco, which are not part of the EU.

The main characteristics of the interconnections with the various countries mentioned are explained below:

- The **interconnection with France** consists of five lines: Hernani-Argia 400 kV, Arkale-Argia 220 kV, Biescas-Pragnères 220 kV, Vic-Baixas 400 kV and Santa Llogaia-Baixas 400 kV.

  The Santa Llogaia-Baixas line is direct current and went into operation in October 2015 through the eastern Pyrenees. It is highly important as it made it possible to double the electrical exchange capacity with this country, reaching a total of 2 200-2 800 MW. It is also important given its influence on the quality and security of the supply and on the capacity for integrating renewable energy.

  Despite this latest line, the need to increase Spain’s capacity for interconnection with the European system continues to be a priority for the Spanish electricity system, as Spain has a long way to go before it can meet the European Union's interconnection targets.

- The **interconnection with Portugal** is formed by 11 lines: Cartelle-Lindoso 400 kV 1 and 2, Conchas-Lindoso 132 kV, Aldeadavila-Lagoaça 400 kV, Aldeadavila-Pocinho 1 and 2 220 kV, Saucelle-Pocinho 220 kV, Cedillo-Falagueira 400 kV, Badajoz-Alcáçovas 66 kV, Brovales-Alqueva 400 kV, Rosal de la Frontera-V.Ficalho 15 kV and Puebla de Guzmán-Tavira 400 kV. These lines have a total exchange capacity between 2 200 and 3 000 MW.

  There are plans to increase this capacity by constructing a new 400 kV line through Galicia between Fontefría (Spain) and Vilafría (Portugal), which will allow to reach a total exchange capacity of about 4 300 MW together with the other existing lines.

- The **interconnection with Andorra** is via the 110-kV Adrall-Margineda line.

- Finally, the **interconnection with Morocco** is via two underwater 400-kV lines, which in total provide an exchange capacity of about 800 MW.

Commercial exchange capacity and ratio for electricity interconnection

The total capacity for effective exchange between two countries not only depends on the nominal capacities of the cross-border lines but also the related network, the distribution of electricity flows with the other interconnections and the location of the generation centres and consumption points. For this reason, the sum of the nominal capacities of the cross-border lines may be significantly lower than the total effective capacity.

The exchange capacity values of the mainland Spanish system with France, Portugal and Morocco are shown below for the period from 2013 to 2018, according to the information provided by the system operator. The exchange capacity values available to the system operator are considered and two values are given, one with the 70th percentile[57] (in line with ENTSO-E[58]) and another with the maximum value (this makes it possible to see more clearly the increase in interconnection capacity in the same year in which this capacity improved).

Table A.38. Commercial capacity for electricity exchange

Commercial capacity for electricity exchange (MW)				
	NTC France -> Spain		NTC Portugal -> Spain	
Year	70th percentile	Maximum value	70th percentile	Maximum value
2013	1 200	1 300	2 000	2 400
2014	1 200	1 300	2 100	2 900
2015	1 300	2 950	3 000	4 000
2016	2 750	3 500	2 800	3 900
2017	2 850	3 500	3 200	4 000
2018[59]	2 900	3 600	3 500	4 000

Source: Red Eléctrica Española

The values of the interconnection ratios presented below were calculated applying the following additional considerations assumed by REE and based on those defined by ENTSO-E:

- To calculate the ratio of the mainland Spanish system, the borders with France and Portugal are considered. Morocco is not considered as it is not subject to the obligations and commitments at European level.
- To calculate the Iberian Peninsula ratio, only the France-Spain border is considered.
- For the purposes of calculating the numerator, the sum of the import capacities from Spain is considered for the period taken into account. The import capacity values are obtained from the hourly Net Transfer Capacity (NTC) values published on eSIOS[60].
- The installed capacity value is the value corresponding to the start of the period considered.

[57] The 70th percentile is the value normally used to determine the exchange capacity of international interconnections. This percentile is used to leave a certain safety margin.

[58] ENTSO-E, the European Network of Transmission System Operators for Electricity, represents 43 transmission system operators (TSOs) from 36 European countries.

[59] Up to 15 June 2018

[60] eSIOS is the information system of the Spanish system operator (REE). https://www.esios.ree.es/es

Table A.39 Development of Spain-Portugal installed electricity generation capacity

Year	Installed capacity Peninsular Spanish system[61] (MW)	Installed capacity Portuguese System (MW)
2013	102 378	18 494
2014	102 908	17 792
2015	102 827	17 776
2016	103 287	18 563
2017	102 371	19 518
2018[1]	101 207	19 800

Source: Red Eléctrica Española

Table A.40 Electricity interconnection ratio

Year		Electricity interconnection ratio: 70th percentile	Maximum	Observations
2013	**Spain**	3.1 %	3.6 %	
	Iberian Peninsula	*1.0 %*	*1.1 %*	
2014	**Spain**	3.2 %	4.1 %	May 2014: Placing in service of the Spain-Portugal southern interconnection (Puebla de Guzmán-Tavira)
	Iberian Peninsula	*1.0 %*	*1.1 %*	
2015	**Spain**	4.2 %	6.8 %	June 2015: Placing in service of the Spain-France interconnection through Catalonia (Santa Llogaia-Baixas)
	Iberian Peninsula	*1.1 %*	*2.5 %*	
2016	**Spain**	5.4 %	7.2 %	
	Iberian Peninsula	*2.3 %*	*2.9 %*	
2017	**Spain**	5.9 %	7.3 %	
	Iberian Peninsula	*2.4 %*	*2.9 %*	
2018[62]	**Spain**	6.3 %	7.5 %	
	Iberian Peninsula	*2.4 %*	*2.9 %*	

Source: Red Eléctrica Española

Projections of interconnector expansion requirements

The Council of Ministers Agreement of 16 October 2015 approved the document 'Energy Planning. Electricity Transmission Network Development Plan 2015-2020' ('Planificación Energética. Plan de Desarrollo de la Red de Transporte de Energía Eléctrica 2015-2020'), provided for in Article 4 of Law 24/2013 of 26 December 2013 on the Electricity Sector and published by Order IET/2209/2015 of 21 October 2015. This plan replaces the part corresponding to the electricity transmission network in the document 'Electricity and Gas Sector Planning 2008-2016' ('Planificación de los Sectores de Electricidad y Gas 2008-2016'), approved by the Council of Ministers on 30 May 2008.

The 2015-2020 plan includes a new 400-kV line through Galicia, called Fontefría-Vilafría, to boost the **Spain-Portugal interconnection**.

Likewise, to improve the **Spain-France interconnection**, a 550-MVA phase shifter was included on the 2015-2020 horizon, located in Arkale between the Arkale substation (Oiartzun, Gipuzkoa) and Argia (France). This is a key element for increasing the capacity for exchange with Europe and the security of supply. This system, declared a Project of Common Interest by the European Union and placed in service on 30 June 2017, involved an investment of EUR 20 m.

[61] Includes the installed capacity in the Balearic Island system from the placing in service of the Peninsula-Mallorca link

[62] Up to 15 June 2018

In addition, Annex II of the Planning 2015-2020 document sets out the electricity transmission network infrastructures, **on a non-binding basis**, that are considered necessary to place in service during the years following the planning horizon (after 2020). The inclusion of an installation in this Annex makes it possible to start the relevant administrative procedures for the abovementioned installations.

Since it has a longer time horizon for implementation, this Annex sets out the following interconnections with France:

- underwater interconnection with France via the Bay of Biscay: Gatika-Cubnezais;
- interconnection through the western Pyrenees: two alternatives, one for interconnection with France from Ichaso or via Navarre (Muruarte);
- interconnection through the central Pyrenees via Aragon (Ejea de los Caballeros).

The system operator continues to manage the projects in these three future interconnections. The consultation and public participation stage for the interconnection via the Bay of Biscay, which is the interconnection with the highest degree of progress, closed in March 2018.

Likewise, the abovementioned Annex II of the planning includes a new Spain-Andorra interconnection, via the double-circuit overhead 220-kV line between the Adrall substation and the Andorran border.

With the placing in service of the underwater interconnection with France via the Bay of Biscay, it will be possible to get a 5 000-MW interconnection with the rest of Europe. Once the trans-Pyrenean projects are placed in service, this interconnection will reach 8 000 MW. It is important to note that the European interconnection targets would still not be reached despite this significant growth in interconnection capacity.

A.5.1.2 Gas system interconnectivity: Current interconnection level and main interconnections

Spain currently has six physical interconnections, four with EU Member States and two with third countries.

Interconnections with France

There are two physical interconnections with France, via the municipalities of Irún (Gipuzkoa) and Larrau (Navarre). These interconnections are managed as a single interconnection or virtual point (VIP Pirineos). The transmission capacities are as follows:

- France-Spain direction: 165 GWh/day firm + 65 GWh/day interruptible
- Spain-France direction: 225 GWh/day

Over the course of 2017, the net importation via this interconnection was 43 TWh, which represents a daily net flow of 121 GWh/day in the North-South direction, although with marked seasonality. The usual flow is therefore France-Spain, although the flow may be reversed on particular occasions.

It is worth bearing in mind that the interconnection capacity of Spain, and in the Iberian Peninsula as a whole, is counted among the smallest in the EU. In 2017 the maximum demand was recorded on 5 December, with 1 772 GWh/day. For that specific day, the firm interconnection capacity with France could only contribute 9 % of the demand, a percentage that would be able to reach up to 13 % taking into account the interruptible capacity.

Interconnections with Portugal

There are two physical interconnections with Portugal, via the municipalities of Badajoz and Tuy (Pontevedra). Like the interconnection with France, these interconnections are managed as a single interconnection or virtual point (VIP Ibérico). The transmission capacities are as follows:

- Portugal-Spain direction: 80 GWh/day
- Spain-Portugal direction: 144 GWh/day

Over the course of 2017, the net exportation via this interconnection was 30 TWh, which represents a daily net flow of 82 GWh/day.

Interconnections with Algeria

There are two physical interconnections with Algeria, both one way in an import direction:

- The Maghreb-Europe Gas Pipeline, which crosses Morocco and enters Spain via the municipality of Tarifa (Cádiz), with a transmission capacity of 444 GWh/day.
  Over the course of 2017, the importation via this interconnection was 86 TWh, which represents a net flow of 237 GWh/day.
- The Medgaz gas pipeline, which enters Spain via the municipality of Almería, with a transmission capacity of 290 GWh/day, which could be increased by an additional 25 % with investments in Algerian territory.
  Over the course of 2017, the importation via this interconnection was 75 TWh, which represents a net flow of 205 GWh/day.

A.5.2 Energy transmission infrastructure

A.5.2.1 Electricity transmission infrastructure

Key characteristics of the existing transmission infrastructure for electricity

In accordance with the information provided by REE, the length of the total national transmission network, as at 31 December 2017, was 43 930 km. Moreover, there were 5 719 busbar connections in substations. For its part, the installed transmission capacity increased to a national total of 86 654 MVA.

The breakdown of lines by voltage level and considering their distribution between the Peninsula and the island systems or non-peninsular territories is shown below.

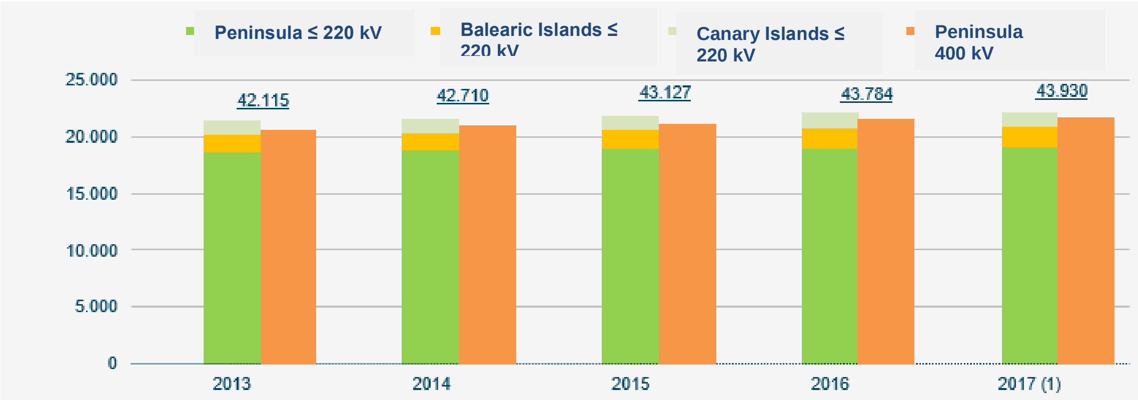
Table A.41 Transmission network installations in Spain

	400 kV	≤ 220 kV			
	Peninsula	Peninsula	Balearic Islands	Canary Islands	Total
Total lines (km)	**21 728**	**19 039**	**1 808**	**1 355**	**43 930**
Overhead lines (km)	21 611	18 264	1 089	1 080	42 045
Subsea cable (km)	29	236	540	30	835
Underground cable (km)	88	539	179	245	1 051
Transformation (MVA)	**80 208**	**613**	**3 273**	**2 560**	**86 654**

Provisional data pending audit in progress.

Source: Red Eléctrica Española

Figure A.1 Development of the transmission network length



Source: Red Eléctrica Española

Table A.42 Development of the transmission network of 400 and ≤ 220 kV (km of circuit)

Year	400 kV	< 220 kV	Year	400 kV	< 220 kV
1978	5 732	13 258	1998	14 538	15 876
1979	8 207	13 767	1999	14 538	15 975
1980	8 518	14 139	2000	14 918	16 078
1981	8 906	13 973	2001	15 364	16 121
1982	8 975	14 466	2002	16 067	16 296
1983	9 563	14 491	2003	16 592	16 344
1984	9 998	14 598	2004	16 841	16 464
1985	10 781	14 652	2005	16 846	16 530
1986	10 978	14 746	2006	17 052	16 753
1987	11 147	14 849	2007	17 191	16 817
1988	12 194	14 938	2008	17 765	17 175
1989	12 533	14 964	2009	18 056	17 307
1990	12 686	15 035	2010	18 792	17 401
1991	12 883	15 109	2011	19 671	18 001
1992	13 222	15 356	2012	20 109	18 370
1993	13 611	15 442	2013	20 639	18 643
1994	13 737	15 586	2014	21 094	18 782
1995	13 970	15 629	2015	21 184	18 922
1996	14 084	15 734	2016	21 619	19 010
1997	14 244	15 776	2017 (1)	21 728	19 039

Source: Red Eléctrica Española

In addition, the transmission network has the following reactive energy and voltage control elements, reactors and capacitors:

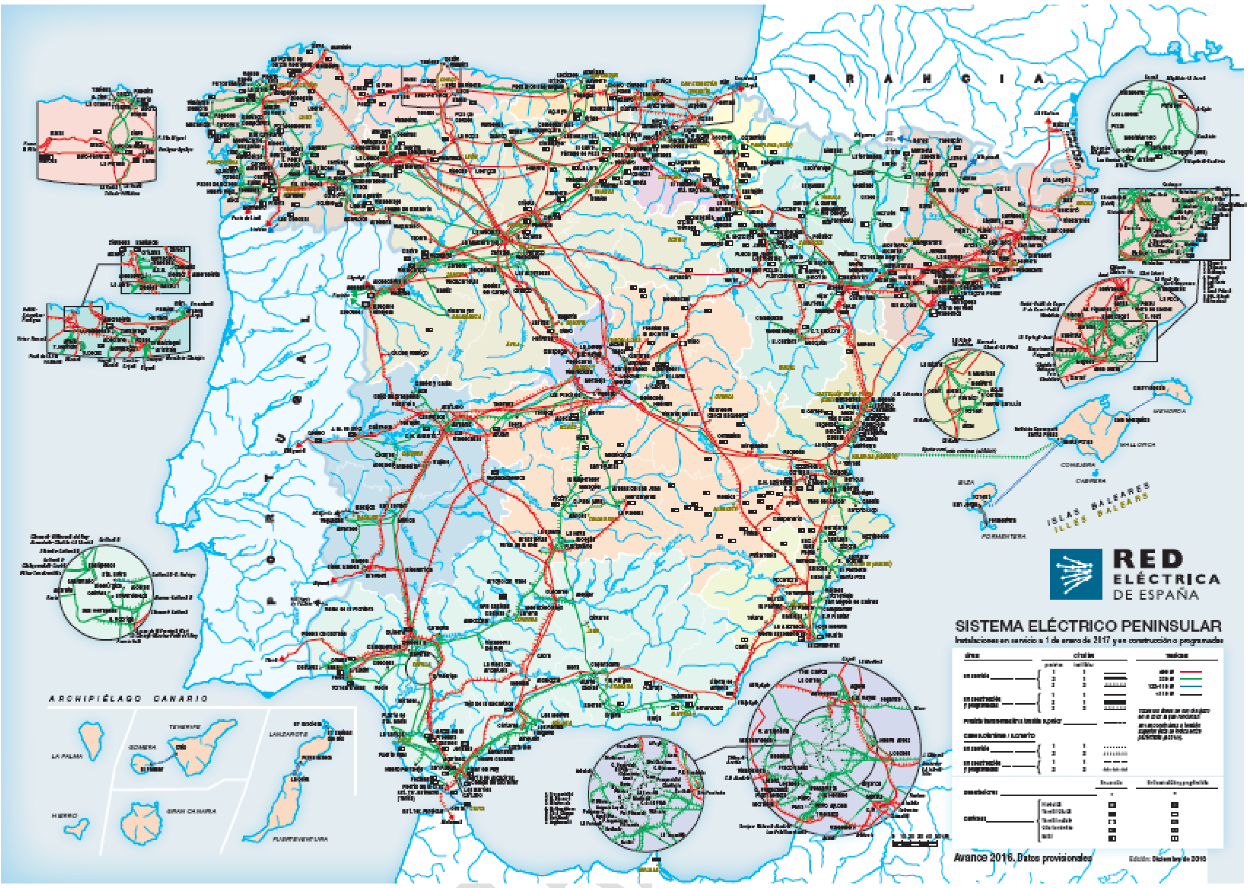
Table A.43 Reactive energy and voltage control elements in the transmission network

	400 kV	≤ 220 kV			
	Península	Península	Baleares	Canarias	Total
Reactancias (MVAr)	**9.050**	**3.414**	**373**	**0**	**12.837**
Número de unidades	62	54	17	0	133
Condensadores (MVAr)	**200**	**1.100**	**0**	**0**	**1.300**
Número de unidades	2	11	0	0	13

Source: Red Eléctrica Española

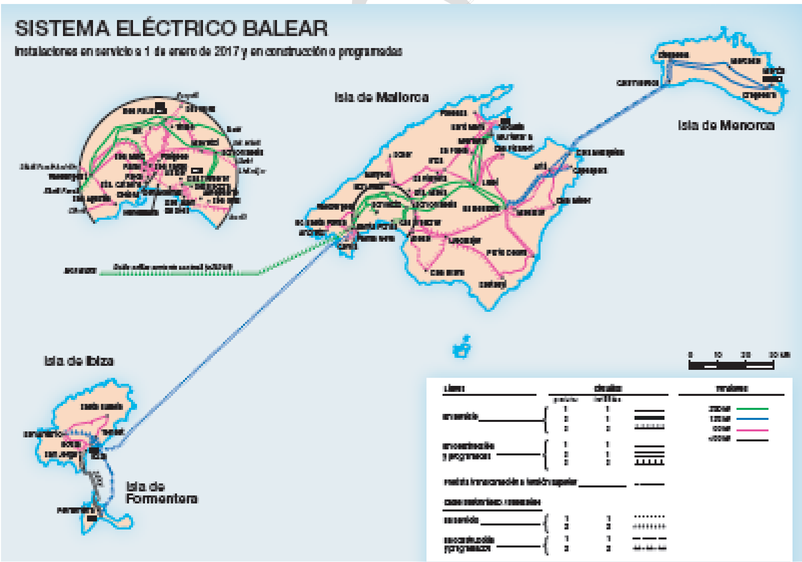
The map of the Spanish electricity system is shown below[63].

Figure A.2 Map of the Peninsular electricity system



Source: Red Eléctrica Española

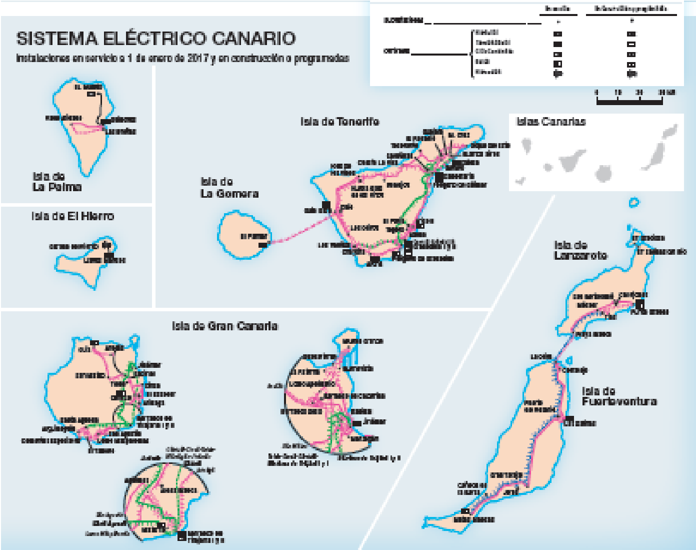
Figure A.3 Map of the Balearic Island electricity system



Source: Red Eléctrica Española

[63] For more details, please see the TSO's web page: http://www.ree.es/es/actividades/gestor-de-la-red-y-transportista/mapas-de-la-red

Figure A.4 Map of the Canary Island electricity system



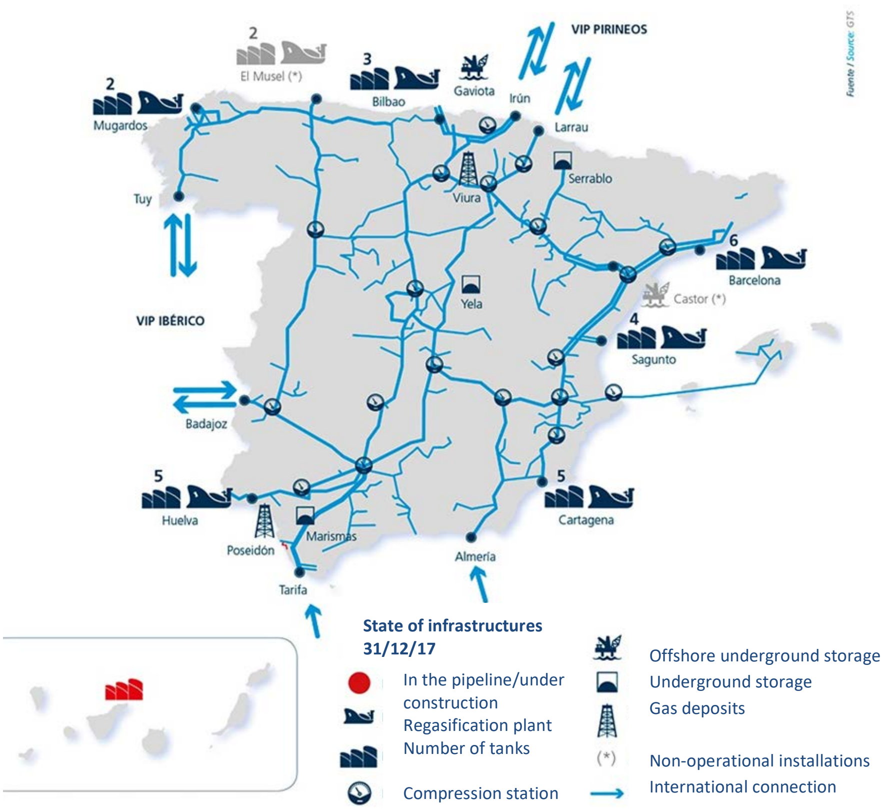
Source: Red Eléctrica Española

A.5.2.2 Gas transmission infrastructure

Key characteristics of the existing transmission infrastructure for gas

Spain has a gas transmission network with sufficient capacity to cope with the needs of supply and delivery to the distribution network in the medium term.

Figure A.5 Gas infrastructure map



Source: Sedigas

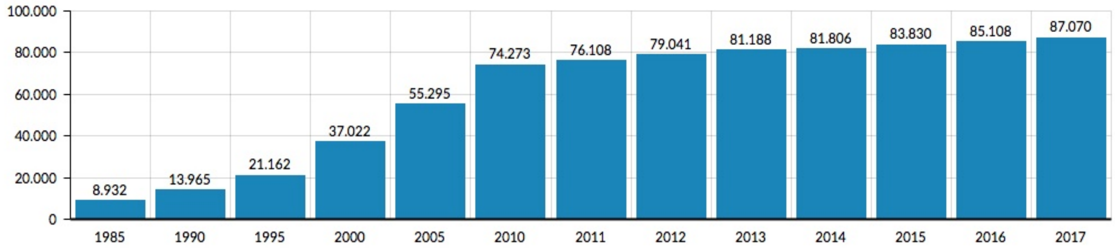
Gas pipeline network

Law 34/1998 on the hydrocarbons sector established the following definitions:

- Gas pipelines for primary transmission of natural gas at high pressure: any gas pipelines with a maximum design pressure equal to or higher than 60 bar.
- Gas pipelines for secondary transmission: any gas pipelines with a maximum design pressure between 60 and 16 bar.
- Distribution gas pipelines: any gas pipelines with a maximum design pressure equal to or less than 16 bar and any others that, regardless of their maximum design pressure, are intended for conducting the gas to a single consumer starting from a gas pipeline in the basic network or secondary transmission pipeline.

As at the end of 2017, there were 11 369 km of primary transmission gas pipeline, 1 992 km of secondary transmission gas pipeline and 74 000 km of distribution gas pipeline, with the transmission and distribution network totalling 87 000 km. The majority of this network is newly built, as shown in the figure below.

Figure A.6 Development of the natural gas transmission and distribution network length (km)



Source: Sedigas

As regards the transmission network, during the 2017 financial year, only two secondary transmission gas pipelines were put into operation:

- the Yeles-Seseña gas pipeline, with a maximum working pressure of 59 bar, length of 9 km and diameter of 8”;
- the Villacarrillo-Villanueva del Arzobispo gas pipeline with a maximum pressure of 49.5 bar, length of 12 km and diameter of 8”.

Lastly, the gas pipeline network has 19 compressor stations that make it possible to transport the gas from the system’s various points of entry to its final destinations, as shown in the figure below.

Regasification plants

At the end of 2017, the gas system had six operational regasification plants, with the following aggregate characteristics:

- Regasification capacity: 1 900 GWh/day
  The plants’ average production in 2017 was 496 GWh/day.
- LNG storage capacity: 3.3 million m^3 of LNG (22.5 TWh).
  The average filling level of the tanks during 2017 was 9.8 TWh.

The table below shows the operational regasification plants and their technical characteristics:

Table A.44 Regasification plants

Plant Regasification	Maximum vaporisation capacity	LNG Storage		Loading capacity of tanks	Berthings	
	Nm^3/h	No of tanks	m^3 LNG	GWh/day	No of berthings	m^3 LNG
Barcelona	1 950 000	6	760 000	15	2	266 000
Huelva	1 350 000	5	619 500	15	1	180 000
Cartagena	1 350 000	5	587 000	15	2	266 000
Bilbao	800 000	3	450 000	5	1	270 000
Sagunto	1 000 000	4	600 000	10.5	1	266 000
Mugardos	412 800	2	300 000	10.5	1	266 000
Total	**6 862 800**	**25**	**3 316 500**	**71**	**8**	**Up to 270 000**

Source: Enagás GTS

Underground storage

At the end of 2017, the gas system had four underground storage facilities, operated as a single storage facility for the purposes of commercial contracting, with the following characteristics:

- Useful storage capacity: 31.7 TWh, excluding cushion gas.
- Stocks varied in 2017 between 17 TWh (February) and 25 TWh (October), of which 17 TWh corresponded to strategic stocks.
- Maximum injection capacity: 127 GWh/day.
- Maximum extraction capacity: 215 GWh/day (most favourable point of the decline curve).

A.5.3 Electricity and gas markets, energy prices

A.5.3.1 Electricity markets and prices

The development of the components of the final price of energy in recent years is shown below.

Table A.45 Average final electricity price components Peninsular demand. Prices in power plant busbars.

Years	Market Daily	Intraday	Adjustment services	Technical restrictions	Payments by capacity	Interrup.	Total
2007	**41.08**	0.00	**0.94**	**1.34**	**3.90**	0.00	**47.26**
2008	**65.91**	0.00	**0.94**	1.66	**1.07**	0.00	**69.57**
2009	**38.17**	**-0.02**	**0.85**	**1.85**	**2.49**	0.00	**43.33**
2010	**38.46**	**-0.02**	1.21	**2.55**	**3.49**	0.00	**45.68**
2011	**50.97**	**-0.06**	1.12	**2.09**	6.10	0.00	**60.22**
2012	**48.84**	**-0.04**	**2.04**	**2.58**	**6.09**	0.00	**59.52**
2013	**46.23**	**-0.06**	**2.30**	**3.29**	**6.04**	0.00	**57.80**
2014	**43.46**	**-0.04**	**1.93**	**3.76**	**5.93**	0.00	**55.05**
2015	**51.67**	0.00	**1.30**	**2.98**	**5.03**	**1.98**	**62.95**

Source: National Commission on Markets and Competition (Comisión Nacional de los Mercados y la Competencia)

A.5.3.2 Gas markets and prices

Current situation of the gas market.

Supplies

In the structure of supplies and flows of gas at entry points, the importance of LNG provision (around 40 %) stands out, as well as the weight of Algeria as the main supplier country (48 % in 2017).

The customs records published by the tax office and analysed by the National Commission on Markets and Competition in its Monitoring Report on the Natural Gas Market in Spain (Informe de Supervisión del Mercado de Gas Natural en España) show the following facts for 2017:

- The average cost of supplies was EUR 17.55/MWh, compared to EUR 15.58/TWh in 2016.
- There is a high correlation between the gas supply prices and the Brent barrel price, given that the price of the majority of Spanish gas marketers' long-term contracts, especially with Algeria, is indexed to the price of oil. This explains the price increase in 2017 compared to 2016.

Wholesale market

Defined as the market made up of the transactions carried out by the marketers in the Spanish gas system, as these transactions are made in regasification plants, underground storage facilities (managed as a single storage facility) or the virtual balancing point (PVB) of the gas pipeline network.

The Spanish wholesale market is characterised by the following:

- Prominence of the over-the-counter market, which concentrated 97.5 % of the transactions in 2017.
- Less trading activity than in other Member States due to the reduced capacity for interconnection with France and, therefore, the reduction of arbitrage opportunities.
- The importance of LNG transactions in regasification plant tanks, forming six additional hubs for the PVB, with the most liquidity being concentrated in the Barcelona plant.
- A significant concentration of the market in a small number of companies. In 2016, the share of transactions notified to the technical system operator by the five companies with the most activity in the market was 45 %.

The main figures characterising the wholesale gas market in Spain are the following:

- The total gas traded on the wholesale over-the-counter market in 2017 was 515 TWh, 150 % of national demand, distributed over 177 000 operations. The majority of these volumes, around 60 %, are negotiated at the PVB, with the remaining 38 % corresponding to regasification plant tanks and barely 2 % to underground storage facilities.
- For their part, the transactions made on the organised wholesale market (MIBGAS), represented a volume of 13.38 TWh, 3.8 % of national demand, distributed over 67 500 transactions. For the moment, only products delivered at the PVB are traded on MIBGAS.

As regards the marginal price of the wholesale market, it can be considered that its dynamics are influenced by the following prices:

- The price of LNG in regasification plant tanks, including the regasification tariff. Logically, the price of LNG in the tanks depends in turn on the price development of the raw material, the cost of methane tanker transport and the unloading tariff.
- The price of the flexible volumes of Algerian gas transported via the Maghreb and Medgaz gas pipelines, indexed to the price of oil.
- The price of the gas in the Southern France balancing area (TRS hub), including the French network output tariff and Spanish network input tariff.

Therefore, the price on the wholesale market is especially sensitive to LNG price movements, as well as price developments in the main EU hubs, although this influence is dampened by the reduced interconnection capacity and high price of the French network output tariff. Precisely, the price at the TRS hub, equally sensitive to LNG prices and increased by the cost of the tariffs, is the one that most closely approximates the price in the Spanish market in the long term.

Organised wholesale market

MIBGAS, the organised gas market, began its operations on 15 December 2015; it is where spot products with delivery at the PVB are traded. There was a significant increase in the number of participants, the volume and number of offers and transactions in the period up to December 2017:

Table A.41. Operations of MIBGAS, the organised gas market

Operations on MIBGAS			
PARAMETER	**2016**	**2017**	**2018 (January-June)**
Number of registered agents	44	65	71
Average daily number of active agents	27	34	45
Volume traded (GWh)	6 566	13 376	11 285
Churn rate (volume traded/national demand)	2.05 %	3.81 %	6.31 %
Intraday product volume (D) (GWh)	2 309	6 299	4 481
Daily product volume (D+1) (GWh)	2 635	4 107	3 010
Daily product volume (M+1) (GWh)	1 005	1 702	2 355

Source: Organised wholesale gas market [64]

As can be observed in the table above, in 2018 a degree of relative maturity was reached in the number of registered and active agents, but the volume of gas traded continued to grow. This trend is especially striking in the case of the monthly product, which in the first half of 2018 exceeded the volume of gas matched in the entire 2017 financial year.

Moreover, the tracking of the gas target model metrics carried out by MIBGAS, the market operator, in its 2017 annual report, shows how these metrics are still relatively far from those marked by the EU's more developed markets, although they made significant progress during the 2017 financial year.

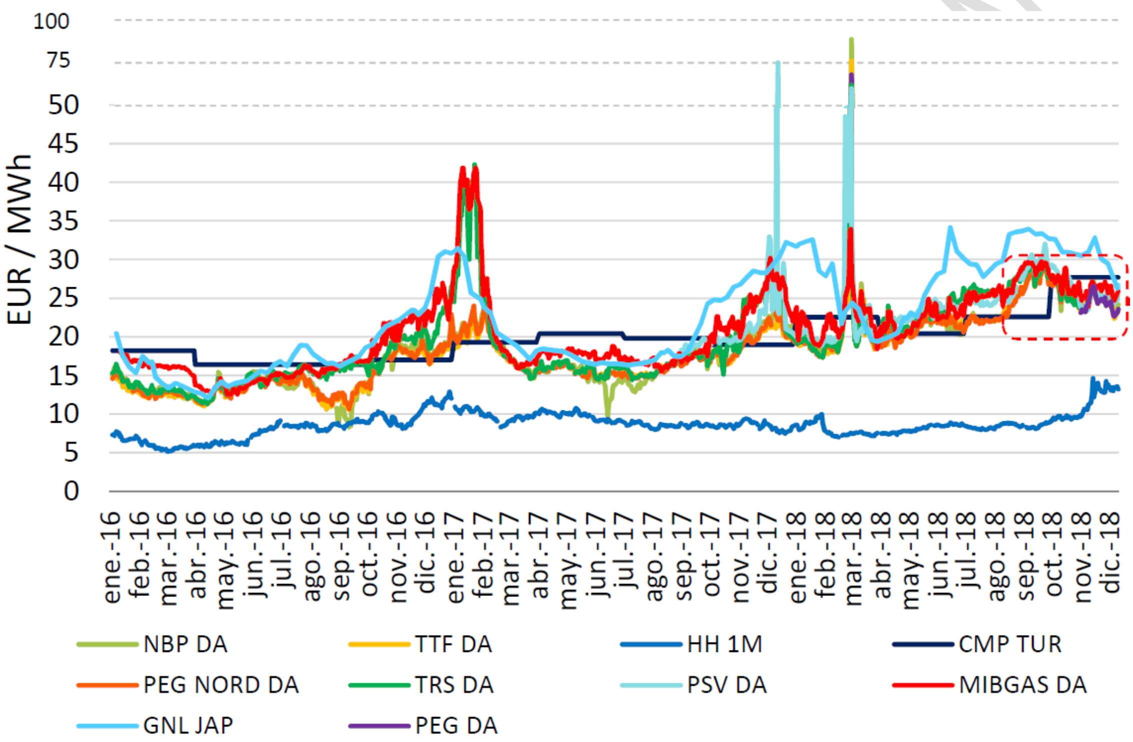
In relation to price development, the month of January 2017 shows how, under certain circumstances, the prices of the markets in southern Europe (MIBGAS and TRS) were uncoupled from the rest of the continent, maintaining average price differentials of EUR 15/MWh with the reference hubs for more than one month. The following circumstances came together in this specific episode:

[64] Agent number data as at 31/12/2016 and 2017; 30/06/2018. Other parameters included during the reference financial year[65] Index used to analyse the level of concentration in a market. The higher the index level, the higher the degree of concentration. An unconcentrated market is usually considered one with values under 1 000, while 1 000 to 1 800 is considered moderately concentrated and above 1 800 is concentrated.

- a cold spell in France and the Iberian Peninsula, with the resulting increase in the domestic gas demand;
- the unavailability of nuclear power plants in France, with the resulting increase in imports of electricity from other Member States, including Spain;
- an increase in the electricity demand in Spain due to the increase in exports, with combined cycle power stations being used for the most part, increasing the gas demand for the electricity sector;
- the purchase of gas by Spanish marketers on the spot market, both in southern France and on the global LNG market.

The table below shows the development of gas prices.

Figure A.7 Gas market price development



Source: Ministry for Ecological Transition

The decoupling phenomenon took place again between October and December 2017, with notably higher prices in the Iberian Peninsula and southern France.

However, during the early months of 2018, the disconnection of MIBGAS with respect to other Community hubs as a result of the reduced physical interconnection capacity and high amount of tariffs, had positive results for the Spanish wholesale market. In effect, the voltages recorded between 28 February and 1 March on the continental markets were barely felt in MIBGAS. Specifically, the daily product price on MIBGAS reached EUR 34/MWh compared to EUR 89/MWh on NBP, EUR 76/MWh, EUR 68/MWh on PEG Nord, and EUR 62/MWh on TRS.

In any case, as can be observed throughout the historical series, the episodes in which the disconnection of the Iberian Peninsula markets determines lower prices than in the rest of the continent are isolated and short in duration, with a structurally higher gas price being confirmed.

Retail

This market is defined as the set of transactions that have taken place between marketers and final consumers.

The main characteristics of the Spanish retail market are as follows:

- a low proportion of supply points with respect to the population, with low penetration in the domestic segment due to the climatology;
- high business concentration, with a high market share of the incumbent operator that maintains most of the distribution network;
- a final sales price of gas that is higher than the EU average.

The main indicators of this market in 2017 are the following:

- number of customers: 7.8 million;
- number of marketers with sales to final customers: 71 marketers, belonging to 54 holding companies.

The market shares are set out in the table below.

Table A.47 Operator shares on the retail gas market

Operator shares on the retail market	
Holding company	**Share of sales volume**
Gas Natural Fenosa	39.6 %
Endesa	16.6 %
Unión Fenosa Gas	8.2 %
Iberdrola	6.8 %
Cepsa	5.0 %
EDP	2.4 %

Source: National Commission on Markets and Competition (Comisión Nacional de los Mercados y la Competencia)

Herfindahl-Hirschman Index[65] (HHI) value is 2 034, having recorded an improvement in the last financial year.

The business concentration in the domestic/commercial segment is even more marked, as Gas Natural Fenosa has an HHI of 3 076 in terms of number of customers. Gas Natural Fenosa concentrates 54 % of customers and 50 % of sales share.

In contrast, there is less concentration on the industrial gas market (HHI 2 134) and the market for electricity generation (HHI 1 631).

Business concentration has been stable for the past six years, with Gas Natural Fenosa between 40 % and 47 %, followed by Endesa, which has been between 15 % and 17 %. There has been a decrease in market share of the five biggest marketers, from 84 % to 76 % of aggregate share, as a result of the growth of small marketers.

- Rate of supplier change: 9.5 % This has remained relatively stable since 2013.
- Number of cut-offs due to non-payment: 19 000 (2.43 cut-offs for every 1 000 customers). This has dropped significantly since 2016.

Two basic tariff types coexist on the retail market:

- a regulated tariff for consumers connected to pressures lower than 4 bar, with annual consumption under 50 000 kWh/year: 21 % of the total customers and 2 % of the sales volume;

[65] Index used to analyse the level of concentration in a market. The higher the index level, the higher the degree of concentration. An unconcentrated market is usually considered one with values under 1 000, while 1 000 to 1 800 is considered moderately concentrated and above 1 800 is concentrated.

- the free market: 79 % of the total customers and 98 % of the sales volume.

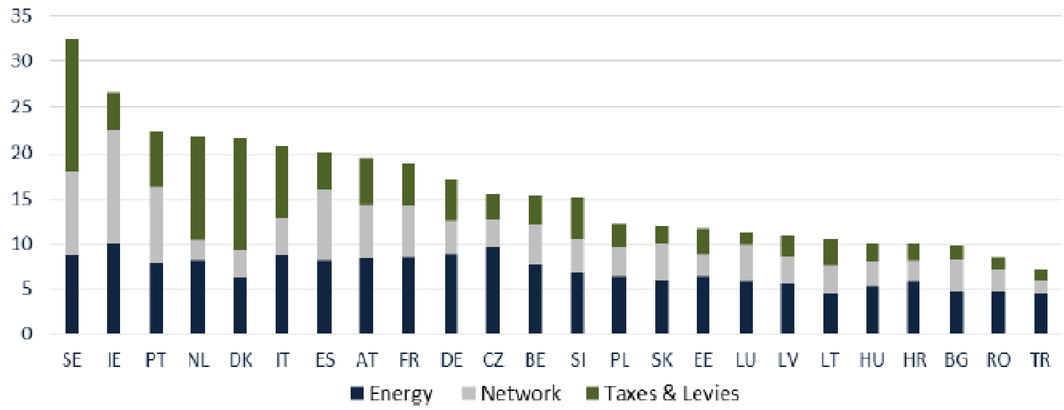
In reference to the final prices for consumers, the CNMC concludes that 'in general, on the domestic market the gas supply offers are, for the most part, referenced to the development of the tariff of last resort'.

The annual cost of the gas supply for a consumer entitled to the tariff of last resort (TUR) was as follows at the end of 2017:

- TUR1: EUR 221.38/year for a consumer with a consumption of 2 500 kWh/year.
- TUR2: EUR 619.50/year for a consumer with a consumption of 9 000 kWh/year.

According to the gas price comparison for a domestic consumer (in the 2 500-5 000 kWh/year band) done by the European Commission, it is confirmed that the price in Spain is the seventh most expensive in the EU, due to both a higher price of the raw material and the cost of the networks.

Figure A.8 Price of natural gas for a domestic consumer in the EU in 2017 (€/GJ)



Source: European Commission

Projections of price development with current policies and measures

The price of gas in Spain on the Plan's projection horizon corresponds with the international price hypotheses for this fuel recommended by the European Commission.

A.6 RESEARCH, INNOVATION AND COMPETITIVENESS

This section shows the current status, as well as the projects for the areas related to research, innovation and competitiveness, a fundamental aspect of a long-term energy policy.

A.6.1 Level of public and private spending on research and innovation

State financing of research, innovation and competitiveness for energy transition and climate change is articulated and executed by means of various instruments and bodies, all attached to the Ministry of Science, Innovation and Universities.

This financing can be broken down into financing for research, innovation and competitiveness projects and financing for public research and development infrastructure. The financing of this effort is channelled via:

- The Centre for the Development of Industrial Technology (Centro Desarrollo Tecnológico e Industrial, CDTI): financing of corporate research, innovation and competitiveness projects.
- Spanish Research Agency (Agencia Estatal de Investigación, AEI): financing for training and attracting research personnel; basic and applied research projects, both national and within the European Research Area or 'ERANETs'.
- The Ministry of Science, Innovation and Universities itself: financing of public-law research bodies.

In the case of the CDTI, in the context of the State Plan, using the year 2017 as reference, the CDTI approved 84 R&D projects in the area of energy, developed by companies with different forms of aid (refundable aid, partially refundable aid and grants).

This aid overall has given rise to a total investment of more than EUR 109 m and public contribution commitments amounting to EUR 76 m[66].

Within the sectoral area of energy, research, innovation and competitiveness to promote renewables and emerging technology accounts for 64.7 % of the projects approved, 57.1 % of public contribution commitments and 68.1 % of the total business investment budget. These sectoral investments in energy represent 6 % of the total operations financed and 9 % of the contribution commitment. It is notable that there is a route and potential for great development in this direction.

Moreover, CDTI is also responsible for managing the company INNVIERTE ES, S.A., S.C.R., whose mission is to promote the investment of risk capital in the Spanish technology sector, boosting innovative or technology-based companies (mainly small and medium-sized

[66] 2017 aid schemes through grants: CIIP (Eurostars projects), Interempresas Internacional sub-programme; INNO, Innoglobal Grants Programme; SERA, Eranet; and SNEO, Neotec grants. The Feder-Innterconecta Programme was not organised for 2017. Permanent CDTI schemes: ID (individual R&D projects), which includes R&I projects, CIEN (large strategic projects in cooperation), strategic projects, EUREKA, IBEROEKA projects, etc.; LIC (technology innovation projects)

[67] ETS: Emission Trading Scheme.

enterprises) and facilitating the stable participation of private capital in the long term by means of investment in public-private vehicles.

The investments in the risk capital vehicles supported by INNVIERTE in the area of energy and environment, as at December 2017, are shown in the table below.

Table A.48 INNVIERTE programme investments in energy and environment

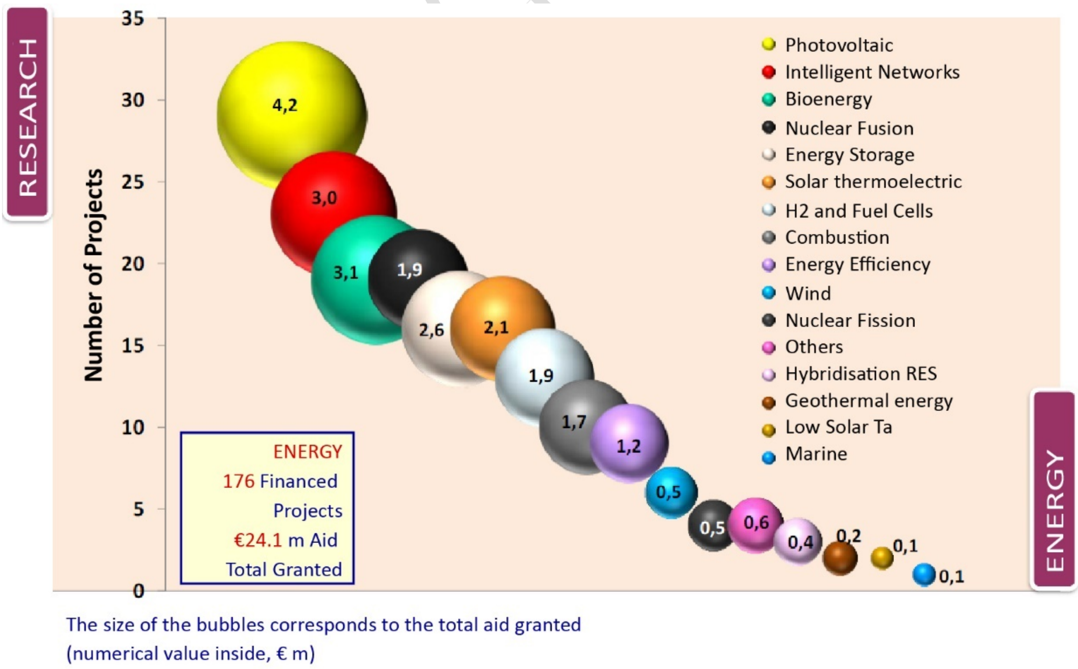
Leading company	Portfolio companies	Funds received by investees (€)
AGBAR	7	10 726 957
Iberdrola	2	1 200 000
Repsol	4	5 507 822

Source: The Centre for the Development of Industrial Technology

The Spanish Research Agency (Agencia Estatal de Investigación, AEI), for its part, manages the financing of the research and development carried out by public research centres and universities, as well as public-private partnership.

Specifically within the national RIC programme geared towards Societal Challenges, and namely for 'Research Challenges' RIC projects in Challenge 3: efficient, secure and clean energy, in the years 2014, 2015 and 2016, a total of 176 projects were financed with EUR 24.1 m in total aid granted.

Figure A.9 Financing of energy projects from the Societal Challenges national research, innovation and competitiveness programme (€ m)



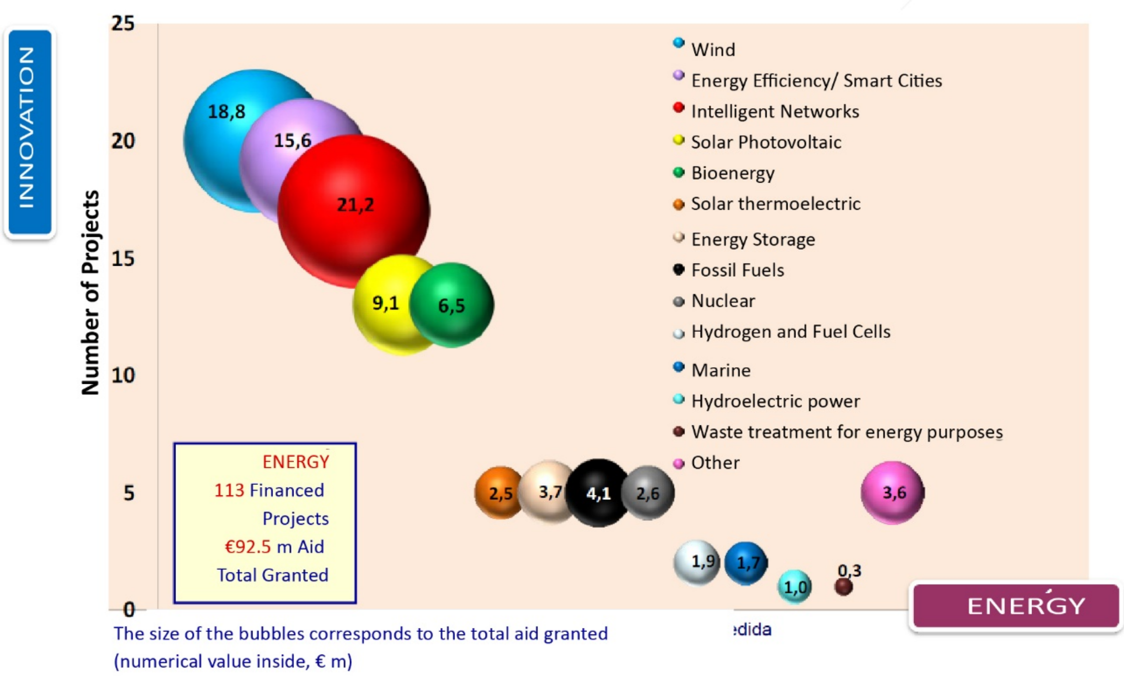
Source: Spanish Research Agency

The largest number of projects financed correspond to photovoltaics, followed by electricity/smart networks, bioenergy, nuclear fusion, energy storage and solar thermoelectric. Next are projects related to hydrogen and fuel cells, combustion/CO_2 and energy efficiency.

Finally, there are smaller lines including wind, nuclear fission, geothermal energy and low-temperature solar, and one project financed related to marine energy. It should be noted that the classification by thematic lines has been made considering the predominant technology in each project, which does not prevent some of them from also including other technologies. Lastly, it is worth highlighting the existence of three projects consisting in research on hybridisation of renewables.

Moreover, within the same national programme, but in the Challenges – Partnership scheme (public-private partnership), in Challenge 3: efficient, secure and clean energy, in the years 2014, 2015 and 2016, a total of 113 projects were financed with EUR 92.5 m in total aid granted.

Figure A.10 Financing of energy projects from the Partnership Challenges national research, innovation and competitiveness programme (€ m)



Source: Spanish Research Agency

Historically, we find two broad clearly differentiated blocks:

In the first of these, with the higher number of projects financed and more aid granted, are the topics of wind energy, energy efficiency/smart cities (these have been considered jointly given the impossibility of separating them), electricity/smart networks, solar photovoltaic and bioenergy.

In the second block, very much behind the first in terms of number of projects financed, are the topics of solar thermoelectric (these are normally small projects related to the resource), energy storage (it is possible that some of the electricity network projects will also include this topic in part), fossil fuels, nuclear fission energy, hydrogen and fuel cells, marine energy (waves), hydroelectric power and others.

A.6.2 Main components of the price of electricity and gas

In terms of electricity, at present the final electricity customer's bill comprises:

The cost of the energy, which includes:

- the cost of the energy on the daily, intraday and adjustment markets;
- the cost of the capacity payments;
- the cost of the interruptibility demand management service on the Peninsula;
- the costs of remuneration to market and system operators.

The access tariffs to cover the costs of the system, which presently include both the access tariffs by which the cost of the transmission and distribution networks is compensated, as well as other charges that basically cover the following items:

- the specific remuneration system for renewables and cogeneration;
- the generation cost overrun in the electricity systems of non-peninsular territories;
- the remuneration of the regulator;
- the tariff deficit annuities;
- the cost of the interruptibility demand management service in the electricity systems of non-peninsular territories.

The marketing margin that may be applied to the billing for energy and/or capacity.
The cost of renting the metering equipment.
Electricity taxes and VAT.

- Currently, the electricity tax is 5.1127 % of the energy and capacity billing.
- VAT is 21 % of the total bill, including the equipment rental cost and electricity tax.

In terms of natural gas, once every six months Spain sends Eurostat the average domestic and industrial natural gas price by consumption band. This information is obtained from the weighted national average by sales of the prices the natural gas marketers send to MITECO.

The price currently is broken down into price with tax, price without VAT and price without tax; nevertheless, work is being done on a future breakdown of the price into three components: energy and supply, networks and taxes, charges and fees. As an example, the average prices sent to Eurostat for the first half of 2018 (latest available) are detailed below.

Table A.49 Average price of domestic and industrial natural gas by consumption bands

Average price of domestic and industrial natural gas by consumption bands First Half of 2018					
Domestic consumption band	**Annual consumption (GJ)**		**Price without tax (€/kWh)**	**Price without VAT (€/kWh)**	**Price with tax (€/kWh)**
D1		< 20	0.0701	0.0724	0.0876
D2	≥ 20	< 200	0.0526	0.055	0.0665
D3		≥ 200	0.0443	0.0466	0.0564
Non-domestic consumption band	**Annual consumption (GJ)**		**Price without tax (€/kWh)**	**Price without VAT (€/kWh)**	**Price with tax (€/kWh)**
I1		< 1 000	0.0367	0.0372	0.045
I2	≥ 1 000	< 10 000	0.0349	0.0354	0.0429
I3	≥ 10 000	< 100 000	0.0285	0.029	0.0351
I4	≥ 100 000	< 1 000 000	0.0241	0.0247	0.0299
I5	≥ 1 000 000	< 4 000 000	0.023	0.0236	0.0285
I6		≥ 4 000 000	0.0229	0.0234	0.0283

Source: Ministry for Ecological Transition, 2019

A.6.3 Description of energy subsidies (including fossil fuels)

Exemptions from the excise duty on hydrocarbons

These are established in Article 9 of Law 38/1992 on excise duties, with points (e) and (f) applying specifically to the excise duty on hydrocarbons.

'1. Without prejudice to the provisions of Articles 21, 23, 42, 51, 61 and 64 of this Law, the manufacture and importation of products subject to manufacturing excise duties intended for the following shall be exempt, under the conditions established by regulation:

(a) delivery in the context of diplomatic or consular relations;

(b) international organisations recognised as such in Spain and members of these organisations, within the limits and under the conditions determined in the international agreements constituting such organisations or in headquarters agreements;

(c) the armed forces of any State, other than Spain, that is party to the North Atlantic Treaty and the armed forces to which Article 1 of Decision 90/6407/EEC refers for use by these forces or of the civilian staff at their service or for the supplying of their canteen facilities and recreation rooms;

(d) consumption under an agreement concluded with non-member countries or international organisations provided that such an agreement is allowed or authorised with regard to exemption from VAT;

(e) the provisioning of the following vessels excluding, in any case, those that carry out private pleasure sailing:

1. those that carry out international maritime navigation;

2. those related to maritime rescue or assistance, excluding the supply of on-board provisions, where the duration of their navigation, without stops, does not exceed 48 hours;

(f) the provisioning of aircraft that carry out international air navigation other than private pleasure flying.'

Reduced rates

Article 50 establishes the tax rates, differentiated according to the use, which causes there to be reduced rates for the following hydrocarbon uses:

- gas oil used as fuel in the agricultural vehicles mentioned in Article 54(2) of the Law and, in general, as fuel (heating): 90.71 euros per 1 000 litres;
- LPG intended for uses other than fuel uses.
- natural gas intended for uses other than fuel uses, as well as natural gas intended for use as fuel in stationary motors;
- natural gas intended for uses for professional purposes provided that they are not used in cogeneration processes and direct or indirect electricity generation;
- kerosene intended for uses other than fuel uses;
- biodiesel for use as fuel in the uses set out in Article 54(2) and, in general, as fuel, and biomethanol for use as fuel;
- gas oil intended for electricity generation or the cogeneration of electricity and heat;
- gas diesel oil intended for electricity generation or the cogeneration of electricity and heat.

A) Quantification

In total, according to the data provided by the National Agency for Tax Administration, the sum in 2017 of the above exemptions and deductions totalled the following amounts for each of the fossil fuels:

- Oil: EUR 2 302 799 622.78
- Natural gas: EUR 756 107 645.06
- Coal: EUR 2 866 278.82

A.7 GOVERNANCE REGULATION 2018/1999 ANNEX TABLES

A.7.1 Annex I Part 2 Baseline Scenario Table

Table A.50 Parameters, variables and balances of the Baseline scenario

		Units	2015	2020	2025	2030
1. Parameters and general variables						
1	Population	millions	46.449570	47	47	47
2	GDP	Billion EUR (constant 2016)	1 070.71	1 223.4	1 333.8	1 421.4
3	Sectoral gross added value	million EUR				
	Agriculture	million EUR				
	Construction	million EUR				
	Services	million EUR				
	Energy sector	million EUR				
	Industry	million EUR				
4	Number of households	millions	18.35	18.53	18.74	19.00
5	Size of households	inhabitants/ household	2.53	2.51	2.50	2.48
6	Disposable income for households	EUR				
7	Passengers-km	millions pkm				
	Buses	millions pkm	54 869.30	56 203.43	57 688.93	58 805.29
	Cars	millions pkm	469 924.14	530 375.08	544 393.36	554 928.08
	Motorcycles	millions pkm	36 400.03	41 498.32	42 595.16	43 419.43
	Rail	millions pkm	33 069.61	36 724.82	37 695.49	38 424.94
	Aviation	millions pkm				
	Internal Navigation	millions pkm				
8	Transport of freight	millions tkm				
	Road	millions tkm	256 689.00	287 321.30	305 287.20	319 213.74
	Rail	millions tkm	10 811.61	12 049.20	12 802.63	13 386.66
	Internal Navigation	millions tkm				
9	International import prices in line with Commission recommendations	EUR/GJ				
	Oil	EUR/GJ	8.02	11.90	15.73	17.33
	Gas	EUR/GJ	6.95	7.59	9.64	10.49
	Coal	EUR/GJ	2.01	2.85	3.16	3.79
10	Prices of coal in ETS in line with Commission recommendations	EUR/tonne CO_2	7.80	15.50	23.30	34.70
11	Hypothesis of the exchange rates with respect to the Euro and the US dollar (if applicable)	Dollar/EUR	1.15	1.27	1.39	1.53
12	Number of heating degree day					
13	Number of cooling degree day					
14	Cost hypothesis of the technologies used in the model with respect to the main relevant technologies					

2. Energy balances and indicators		Units	2015	2020	2025	2030
2.1 Energy supply						
1	**Indigenous production per fuel type**	ktoe	**33 615.00**	**37 004.14**	**37 625.60**	**40 458.30**
	Coal	ktoe	1 246.00	1 145.07	0.00	0.00
	Crude oil and petroleum products	ktoe	236.00	310.33	312.37	314.40
	Natural gas	ktoe	54.00	23.51	23.66	23.81
	Nuclear energy	ktoe	14 927.00	15 032.53	15 032.53	15 032.53
	Renewable energy sources	ktoe	16 899.00	19 566.63	21 375.75	24 368.67
	Waste	ktoe	252.01	926.06	881.29	718.88
2	**Net imports by type of fuel (including electricity and divided by net intra-European and extra-European imports)**	ktoe	**89 400.00**	**90 540.86**	**89 669.34**	**88 361.22**
	Coal	ktoe	12 468.00	10 295.24	7 607.27	6 552.36
	Crude oil and petroleum products	ktoe	52 713.00	51 549.96	52 053.92	51 880.14
	Natural gas	ktoe	24 484.00	26 989.38	28 212.41	29 836.99
	Electricity	ktoe	-11.00	761.82	966.94	-380.38
	Renewable energy sources	ktoe	-253.00	944.48	828.80	472.12
3	**Dependence on imports from third countries**	%	**73.00 %**	**70.99 %**	**70.44 %**	**68.59 %**
4	**Main import sources (countries) with the main energy vectors (including gas and electricity)**					
	First country (specify country) of origin of electricity imports	**% of the total imports**				
	First country (specify country) of origin of gas imports	**% of the total imports**				
	Second country (specify country) of origin of gas imports	**% of the total imports**				
	Third country (specify country) of origin of gas imports	**% of the total imports**				
5	**Gross domestic consumption by type of fuel**	ktoe	**123 015.00**	**127 545.00**	**127 294.94**	**128 819.52**
	Coal	ktoe	13 714.00	11 440.31	7 607.27	6 552.36
	Crude oil and petroleum products	ktoe	52 949.00	51 860.29	52 366.28	52 194.54
	Natural gas	ktoe	24 538.00	27 012.88	28 236.06	29 860.80
	Nuclear energy	ktoe	14 927.00	15 032.53	15 032.53	15 032.53
	Electricity	ktoe	-11.00	761.82	966.94	-380.38
	Renewable energy sources	ktoe	16 646.00	20 833.31	22 499.10	25 049.96
	Waste	ktoe	252.01	603.85	586.74	509.70
2.2. Electricity and heat						
1	**Gross electricity production**	GWhe	**286 320.00**	**279 280.95**	**279 301.22**	**300 219.36**
2	**Gross electricity production by fuel**					
	Nuclear energy	GWhe	57 305.00	57 693.36	57 693.36	57 693.36
	Coal	GWhe	128 946.00	47 437.51	28 981.23	23 820.19
	Crude oil and petroleum products	GWhe		6 432.36	5 792.30	5 063.64
	Natural gas	GWhe		4 7162.77	4 2442.90	4 3265.74
	Biomass and waste	GWhe	4 687.00	6 524.02	6 623.43	7 468.01
	Hydroelectric (excluding pumping)	GWhe	28 140.00	28 281.87	28 281.87	28 281.87
	Wind	GWhe	49 325.00	60 511.12	75 224.76	90 991.43
	Solar	GWhe	13 862.00	20 100.46	29 089.78	38 048.54
	Geothermal and other renewable energy sources	GWhe	822.00	447.50	481.58	896.59
	Pumping	GWhe	3 233.00	4 689.99	4 689.99	4 689.99
	Other	GWhe	0.00	0.00	0.00	0.00
3	**Share of electricity generation from cogeneration in total electricity generation (Electricity generated in cogeneration divided by the total gross electricity generated, including generation in pumping)**	%	10.50 %	9.69 %	8.10 %	4.61 %
	Share of the heat generated in the cogeneration in the total heat generated (heat generated in cogeneration divided by the total heat of district heating)	%				
4	**Electricity generation capacity by source, including dismantling and new investments**	GW	**105.62**	**113.09**	**116.04**	**124.49**
	Nuclear energy	GW	7.40	7.40	7.40	7.40
	Coal	GW	11.36	10.57	4.53	4.53
	Crude oil and petroleum products	GW	3.38	3.36	3.19	3.02
	Natural gas	GW	31.59	31.15	30.38	29.04
	Biomass and waste	GW	1.48	1.56	1.50	1.48
	Hydroelectric (excluding pumping)	GW	15.75	15.75	15.75	15.75
	Wind	GW	22.93	27.97	32.97	37.97
	Solar	GW	7.15	10.71	15.71	20.68
	Geothermal and other renewable energy sources	GW	0.22	0.23	0.23	0.23
	Pumping	GW	4.39	4.39	4.39	4.39
	Other	GW	0.00	0.00	0.00	0.00
5	**Heat generation through thermal installations**	GWhe				
6	Heat generation through cogeneration plants, including industrial waste heat	GWhe		29 305.43	24 173.77	14 270.81
7	**Capacity of cross-border interconnection facilities for gas and electricity and their expected utilisation rates**					

2.3. Processing sector		Units	2015	2020	2025	2030
1	**Fuel contributions for the generation of thermal energy**	**ktoe**	23 692.22	21 911.95	16 684.67	14 805.22
	Coal	ktoe	11 868.32	10 320.00	6 300.12	5 178.18
	Crude oil and petroleum products	ktoe	3 563.87	2 041.84	1 902.02	1 744.64
	Natural gas	ktoe	8 260.04	9 550.12	8 482.52	7 882.40
2	**Fuel contributions for other conversion processes**	**ktoe**				
2.4. Energy consumption						
1	**Primary energy consumption (includes non-energy consumption)**	**ktoe**	**123 015.00**	**127 545.00**	**127 294.94**	**128 819.52**
1	**Final energy consumption (includes non-energy consumption)**	**ktoe**	**84 542.00**	**91 781.35**	**94 016.63**	**95 135.89**
2	***Final energy consumption by sector (includes non-energy consumption)***					
	Industry	ktoe	18 064.00	22 363.10	23 337.60	24 008.55
	Residential	ktoe	14 998.00	14 072.86	13 605.91	13 172.16
	Tertiary	ktoe	10 710.00	10 901.32	11 082.41	10 999.19
	Transport	ktoe	29 542.00	37 117.08	38 311.04	39 004.75
	Agriculture	ktoe	2 502.40	2 921.65	2 998.87	3 056.90
	Breakdown between passenger and freight transport, where available					
	Passenger transport	ktoe		27 387.32	28 127.38	28 374.63
	Freight transport	ktoe		9 729.77	10 183.65	10 630.12
3	***Final energy consumption by fuel (includes non-energy consumption)***					
	Coal	ktoe	1 522.00	1 337.00	1 395.39	1 426.92
	Crude oil and petroleum products	ktoe	40 330.00	40 746.74	40 910.28	40 452.42
	Natural gas	ktoe	13 139.00	18 183.52	19 985.40	21 059.98
	Electricity	ktoe	19 951.00	20 332.00	20 612.47	20 996.26
	Heat	ktoe				
	Renewable energy sources	ktoe	5 287.00	6 470.35	6 121.84	5 993.72
	Waste	ktoe	2.00	306.40	310.45	312.25
4	**Final non-energy consumption**	**ktoe**	4 311.00	4 405.34	4 680.80	4 894.33
5	**Primary energy intensity of the general economy (primary energy consumption/GDP)**	**toe/EUR million**	**115.00**	**104.26**	**95.44**	**90.63**
6	**Final energy intensity by sector**					
	Industry	toe/EUR of added value				
	Residential	toe/EUR of added value				
	Tertiary	toe/EUR of added value				
	Breakdown between passenger and freight transport, where available					
	Passenger transport	toe/millions pkm				
	Freight transport	toe/millions tkm				

2.7. Renewable energy		Units	2015	2020	2025	2030
1	**Gross final energy consumption from renewable sources and the share of renewable energy in gross final energy consumption and by sector and technology**					
	Share of renewable energy in final gross energy consumption	**%**	**16.00 %**	**18.59 %**	**21.87 %**	**24.65 %**
	Heating and cooling	%	16.84 %	15.12 %	19.58 %	21.54 %
	Electricity	%	37.00 %	40.47 %	48.51 %	56.27 %
	Transport	%	1.00 %	10.05 %	9.20 %	11.36 %
	Contribution of final renewable energy consumption in transport to the general objective	%		2.55 %	2.27 %	2.25 %
	Contribution of biofuel and biogas included in section A of the list in Annex IX consumed in transport	%		0.86 %	1.12 %	1.58%
	Contribution of biofuel and biogas included in section B of the list in Annex IX consumed in transport	%		0.00 %	0.08 %	0.97 %
	Contribution of biofuels consumed in transport produced from food crops	%		5.35 %	4.38 %	2.97 %
	Contribution of other biofuels consumed in transport	%				
	Gross final consumption of renewable energy in heating and cooling	ktoe	4 663.00	4 665.69	6 548.67	7 401.67
	Production of renewable energy	ktoe	8 642.00	9 834.74	11 889.42	14 045.14
	Gross final renewable energy consumption in transport	ktoe	176.00	2 997.12	3 106.86	3 666.94
	Total gross final renewable energy consumption	ktoe	13 481.00	16 807.37	20 575.53	23 598.14
	Gross final consumption of residual heat and cold in heating and cooling	ktoe				
	Contribution of residual heat and cold in gross final consumption of heating and cooling	%				
	Gross final consumption of renewable energy in district heating and cooling	ktoe				
	Contribution of renewable energy from district heating and cooling to final gross consumption of heating and cooling	%				
	district cooling	ktoe				
	Contribution of residual heat and cold in district heating and cooling in the final gross consumption of heating and cooling	%				
2	**Renewables in buildings (as defined in Article 2(1) of Directive 2010/31/EU), disaggregated data on energy produced, consumed and injected into the network by means of photovoltaic solar systems, solar thermal systems, biomass, heat pumps and systems, must be included**					
3	**Where appropriate, other national trajectories, including long-term or sector-based ones (the share of advanced biofuels produced from food crops, the share of renewable energy in district heating, as well as renewable energy produced by cities and energy communities as defined in Article 22 of (recast) Directive 2009/28/EC, proposed by COM(2016) 767**					
	Share of biofuels from food crops	%		5.35 %	4.38 %	2.97 %
	Advanced biofuel quota	%		0.86 %	1.20 %	2.55 %

3. Indicators related to emissions and absorption		Units	2015	2020	2025	2030
1	**GHG emissions by sector (ETS, Regulation on distribution of efforts and LULUCF)**	**teq.CO_2**	**335 809 458**	**331 734 107**	**315 709 973**	**310 632 069**
	ETS Emissions (2013 ETS areas)	teq.CO_2	139 751 465	129 091 755	114 209 161	113 166 752
	Regulation on the distribution of efforts (in the 2013 areas)	teq.CO_2	196 057 993	202 642 352	201 500 812	197 465 317
	LULUCF (counted in accordance with the requirements of EU law)	teq.CO_2	-42 007 067	-35 281 478	-32 520 218	-31 588 501
2	**GHG emissions by IPCC sector and by gas (when relevant, broken down into ETS and RRE)**	**teq.CO_2**				
	Transformation, primary energy and exchanges	teq.CO_2	16 796 815	18 142 975	18 705 209	19 256 878
	Agriculture	teq.CO_2	34 532 980	34 622 675	34 578 946	34 534 945
	Electricity generation	teq.CO_2	74 050 523	58 750 283	42 063 999	40 899 547
	Industry (combustion)	teq.CO_2	40 462 329	42 045 632	42 203 889	41 217 549
	Industry (processes)	teq.CO_2	21 036 000	21 520 089	22 042 913	22 450 715
	Residential	teq.CO_2	17 212 310	16 113 704	15 243 228	14 430 510
	Tertiary	teq.CO_2	10 923 001	13 190 675	13 922 829	13 279 814
	Transport	teq.CO_2	83 197 462	89 851 024	91 888 365	92 130 564
3	**Coal intensity of the general economy**	**teq.CO_2/GDP (Millions EUR)**	**313.63**	**271.17**	**236.71**	**218.55**
4	**Indicators related to CO_2 emissions**					
a	**Carbon intensity of electricity and steam production**	**teq.CO_2/MWh**	**0.26**	**0.21**	**0.15**	**0.14**
b	**Carbon intensity of final energy demand by sector**	**teq.CO_2/toe**				
	Industry	teq.CO_2/toe	2.24	1.88	1.81	1.72
	Residential	teq.CO_2/toe	1.15	1.15	1.12	1.10
	Tertiary	teq.CO_2/toe	1.02	1.21	1.26	1.21
	Passenger transport	teq.CO_2/toe	2.82	2.42	2.40	2.36
	Freight transport	teq.CO_2/toe	IE	IE	IE	IE
5	**Parameters related to emissions other than CO_2**					
a	**Livestock**					
	Dairy cattle	1 000 head	848.7	816.2	797.7	779.3
	Cattle other than dairy cattle	1 000 head	5 359.8	5 557.6	5 562.7	5 567.7
	Pigs	1 000 head	27 677.9	29 228.0	30 279.7	31 331.4
	Sheep	1 000 head	16 026.4	15 159.6	14 155.4	13 151.2
	Poultry	1 000 head	127 143.1	131 016.3	131 260.2	131 504.2
b	**Contributions of nitrogen resulting from the application of synthetic fertilisers**	**kt nitrogen**	**1 068**	**1 000**	**1 000**	**1 000**
c	**Contributions of nitrogen resulting from the application of manure**	**kt nitrogen**	**442**	**460**	**464**	**468**
d	**Nitrogen fixed by nitrogen-fixing crops**	**kt nitrogen**	**NE**	**NE**	**NE**	**NE**
e	**Nitrogen in crop residues that return to soil**	**kt nitrogen**	**120**	**123**	**126**	**129**
f	**Area of cultivated organic soils**	**hectares**	**NO**	**NO**	**NO**	**NO**
g	**Municipal solid waste generation (MSW)**	**t**	**21 158 000**	**21 754 011**	**21 887 610**	**22 021 208**
h	**Municipal solid waste (MSW) deposited in landfills**	**t**	**12 129 000**	**11 094 545.7**	**10 391 938.7**	**9 689 331.7**
i	**Proportion of CH_4 recovered from the total CH_4 generated in landfills**	**%**	**18.0 %**	***0.18***	***0.2***	***0.2***

Source: Ministry for Ecological Transition, 2019

A.7.2 Annex I Part 2 Target Scenario Table

Table A.51 Parameters, variables and balances of the Target scenario

1		Units	2015	2020	2025	2030
1. Parameters and general variables						
1	Population	millions	46.449570	47	47	47
2	GDP	Billion EUR (constant 2016)	1 070.71	1 223.4	1 333.8	1 421.4
3	Sectoral gross added value	million EUR				
	Agriculture	million EUR				
	Construction	million EUR				
	Services	million EUR				
	Energy sector	million EUR				
	Industry	million EUR				
4	Number of households	millions	18.35	18.53	18.74	19.00
5	Size of households	inhabitants/ household	2.53	2.51	2.50	2.48
6	Disposable income for households	EUR				
7	Passengers-km	millions pkm				
	Buses	millions pkm	54 869.30	56 166.05	82 070.92	108 285.97
	Cars	millions pkm	469 924.14	529 765.18	480 527.89	425 580.88
	Motorcycles	millions pkm	36 400.03	41 353.16	42 079.31	42 620.79
	Rail	millions pkm	33 069.61	36 696.91	62 111.12	87 957.72
	Aviation	millions pkm				
	Internal Navigation	millions pkm				
8	Transport of freight	millions tkm				
	Road	millions tkm	256 689.00	287 321.30	294 090.17	296 230.61
	Rail	millions tkm	10 811.61	12 049.20	23 769.21	35 429.87
	Internal Navigation	millions tkm				
9	International import prices in line with Commission recommendations	EUR/GJ				
	Oil	EUR/GJ	8.02	11.90	15.73	17.33
	Gas	EUR/GJ	6.95	7.59	9.64	10.49
	Coal	EUR/GJ	2.01	2.85	3.16	3.79
10	Prices of coal in ETS in line with Commission recommendations	EUR/tonne CO_2	7.80	15.50	23.30	34.70
11	Hypothesis of the exchange rates with respect to the Euro and the US dollar (if applicable)	Dollar/EUR	1.15	1.27	1.39	1.53
12	Number of heating degree day					
13	Number of cooling degree day					
14	Cost hypothesis of the technologies used in the model with respect to the main relevant technologies					

2. Energy balances and indicators		Units	2015	2020	2025	2030
2.1 Energy supply						
1	**Indigenous production per fuel type**	**ktoe**	**33 615.00**	**36 718.80**	**42 891.70**	**41 822.93**
	Coal	ktoe	1 246.00	1 109.95	0.00	0.00
	Crude oil and petroleum products	ktoe	236.00	310.33	312.37	314.40
	Natural gas	ktoe	54.00	23.51	23.66	23.81
	Nuclear energy	ktoe	14 927.00	15 030.50	15 030.50	6 461.96
	Renewable energy sources	ktoe	16 899.00	19 796.79	26 997.62	34 301.27
	Waste	ktoe	252.01	447.71	527.55	721.49
2	**Net imports by type of fuel (including electricity and divided by net intra-European and extra-European imports)**	**ktoe**	**89 400.00**	**88 008.35**	**72 602.31**	**61 313.16**
	Coal	ktoe	12 468.00	10 226.58	4 362.24	1 127.85
	Crude oil and petroleum products	ktoe	52 713.00	50 688.26	45 140.91	37 834.77
	Natural gas	ktoe	24 484.00	26 474.21	23 477.54	24 506.88
	Electricity	ktoe	-11.00	-334.99	-1 351.05	-2 730.98
	Renewable energy sources	ktoe	-253.00	954.29	972.68	574.63
3	**Dependence on imports from third countries**	**%**	**73.00 %**	**70.56 %**	**62.86 %**	**59.44 %**
4	**Main import sources (countries) with the main energy vectors (including gas and electricity)**					
	First country (specify country) of origin of electricity imports	**% of the total imports**				
	First country (specify country) of origin of gas imports	**% of the total imports**				
	Second country (specify country) of origin of gas imports	**% of the total imports**				
	Third country (specify country) of origin of gas imports	**% of the total imports**				
5	**Gross domestic consumption by type of fuel**	**ktoe**	**123 015.00**	**124 727.15**	**115 494.01**	**103 136.09**
	Coal	ktoe	13 714.00	11 336.53	4 362.24	1 127.85
	Crude oil and petroleum products	ktoe	52 949.00	50 998.60	45 453.28	38 149.18
	Natural gas	ktoe	24 538.00	26 497.71	23 501.20	24 530.70
	Nuclear energy	ktoe	14 927.00	15 030.50	15 030.50	6 461.96
	Electricity	ktoe	-11.00	-334.99	-1 351.05	-2 730.98
	Renewable energy sources	ktoe	16 646.00	20 855.81	28 093.04	35 066.20
	Waste	ktoe	252.01	342.99	404.80	531.18
2.2. Electricity and heat						
1	**Gross electricity production**	**GWhe**	**286 320.00**	**288843.31**	**305518.46**	**337447.91**
2	**Gross electricity production by fuel**					
	Nuclear energy	GWhe	57 305.00	57 685.56	57 685.56	24 800.35
	Coal	GWhe	128 946.00	47 271.13	15 094.26	0.00
	Crude oil and petroleum products	GWhe		7 436.80	6 125.29	4 725.18
	Natural gas	GWhe		56 854.65	35 907.61	50 488.04
	Biomass and waste	GWhe	4 687.00	5 554.25	7 674.00	13 800.63
	Hydroelectric (excluding pumping)	GWhe	28 140.00	28 281.87	28 663.49	29 045.11
	Wind	GWhe	49 325.00	60 521.11	92 053.23	116 110.08
	Solar	GWhe	13 862.00	20 100.46	56 070.76	88 951.42
	Geothermal and other renewable energy sources	GWhe	822.00	447.50	634.46	1 157.91
	Pumping	GWhe	3 233.00	4 689.99	5 609.79	8 369.19
	Other	GWhe	0.00	0.00	0.00	0.00
3	**Share of electricity generation from cogeneration in total electricity generation (Electricity generated in cogeneration divided by the total gross electricity generated, including generation in pumping)**	%	10.50 %	9.37 %	7.60 %	5.28 %
	Share of the heat generated by cogeneration in the total heat generated (heat generated by cogeneration divided by the total heat of district heating)	%				
4	**Electricity generation capacity by source, including dismantling and new investments**	**GW**	**105.62**	**113.15**	**137.12**	**156.97**
	Nuclear energy	**GW**	7.40	7.40	7.40	3.18
	Coal	**GW**	11.36	10.57	4.53	0.00
	Crude oil and petroleum products	**GW**	3.38	3.36	2.84	2.32
	Natural gas	**GW**	31.59	31.15	30.52	30.15
	Biomass and waste	**GW**	1.48	1.63	1.83	2.43
	Hydroelectric (excluding pumping)	**GW**	16.79	15.75	16.00	16.25
	Wind	**GW**	22.93	27.97	40.26	50.26
	Solar	**GW**	7.15	10.71	28.21	44.18
	Geothermal and other renewable energy sources	**GW**	0.22	0.23	0.27	0.31
	Pumping	**GW**	3.34	4.39	5.26	7.89
	Other	**GW**	0.00	0.00	0.00	0.00
5	**Heat generation through thermal installations**	**GWhe**				
6	Heat generation through cogeneration plants, including industrial waste heat	**GWhe**		29 305.43	24 714.87	18 655.51
7	**Capacity of cross-border interconnection facilities for gas and electricity and their expected utilisation rates**					

2.3. Processing sector		Units	2015	2020	2025	2030
1	**Fuel contributions for the generation of thermal energy**	**ktoe**	23 692.22	23 783.67	12 799.41	10 910.80
	Coal	ktoe	11 868.32	10 284.87	3 281.29	0.00
	Crude oil and petroleum products	ktoe	3 563.87	2 408.84	2 023.68	1 620.96
	Natural gas	ktoe	8 260.04	11 089.96	7 494.45	9 289.84
2	**Fuel contributions for other conversion processes**	**ktoe**				
2.4. Energy consumption						
1	**Primary energy consumption (includes non-energy consumption)**	**ktoe**	**123 015.00**	**124 727.15**	**115 494.01**	**103 136.09**
1	**Final energy consumption (includes non-energy consumption)**	**ktoe**	**84 542.00**	**88 994.07**	**85 543.60**	**79 278.81**
2	***Final energy consumption by sector (includes non-energy consumption)***					
	Industry	ktoe	18 064.00	21 840.41	21 948.38	21 951.81
	Residential	ktoe	14 998.00	13 500.96	12 617.34	11 710.29
	Tertiary	ktoe	10 710.00	10 743.11	10 612.95	10 299.63
	Transport	ktoe	29 542.00	35 582.60	32 709.25	27 390.30
	Agriculture	ktoe	2 502.40	2 921.65	2 974.88	3 032.45
	Breakdown between passenger and freight transport, where available					
	Passenger transport	ktoe		26 473.06	24 371.26	20 354.10
	Freight transport	ktoe		9 109.54	8 337.98	7 036.20
3	***Final energy consumption by fuel (includes non-energy consumption)***					
	Coal	ktoe	1 522.00	1 239.42	1 089.54	1 040.45
	Crude oil and petroleum products	ktoe	40 330.00	39 689.89	34 527.55	27 652.68
	Natural gas	ktoe	13 139.00	16 218.44	16 700.52	15 676.55
	Electricity	ktoe	19 951.00	20 104.64	20 537.31	21 579.08
	Heat	ktoe				
	Renewable energy sources	ktoe	5 287.00	7 073.31	7 701.83	8 073.36
	Waste	ktoe	2.00	263.03	306.05	362.37
4	**Final non-energy consumption**	**ktoe**	4 311.00	4 405.34	4 680.80	4 894.33
5	**Primary energy intensity of the general economy (primary energy consumption/GDP)**	**toe/EUR million**	**115.00**	**101.96**	**86.59**	**72.56**
6	**Final energy intensity by sector**					
	Industry	toe/EUR of added value				
	Residential	toe/EUR of added value				
	Tertiary	toe/EUR of added value				
	Breakdown between passenger and freight transport, where available					
	Passenger transport	toe/millions pkm				
	Freight transport	toe/millions tkm				

2.7. Renewable energy		Units	2015	2020	2025	2030
1	**Gross final energy consumption from renewable sources and the share of renewable energy in gross final energy consumption and by sector and technology**					
	Share of renewable energy in final gross energy consumption	**%**	**16.00 %**	**19.99 %**	**30.98 %**	**41.83 %**
	Heating and cooling	%	16.84 %	18.09 %	27.53 %	34.04 %
	Electricity	%	37.00 %	40.69 %	64.67 %	82.31 %
	Transport	%	1.00 %	10.17 %	12.31 %	22.20 %
	Contribution of final renewable energy consumption in transport to the general objective	%		2.61 %	2.35 %	1.97 %
	Contribution of biofuel and biogas included in section A of the list in Annex IX consumed in transport	%		0.04 %	0.06 %	0.11 %
	Contribution of biofuel and biogas included in section B of the list in Annex IX consumed in transport	%		0.00 %	0.89 %	1.69 %
	Contribution of biofuels consumed in transport produced from food crops	%		5.60 %	5.18 %	3.93 %
	Contribution of other biofuels consumed in transport	%				
	Gross final consumption of renewable energy in heating and cooling	ktoe	4 663.00	5 427.63	8 684.99	10 659.19
	Production of renewable energy	ktoe	8 642.00	9 793.43	15 777.91	20 988.45
	Gross final renewable energy consumption in transport	ktoe	176.00	3 003.75	3 845.36	5 188.13
	Total gross final renewable energy consumption	ktoe	13 481.00	17 503.82	26 469.29	33 216.05
	Gross final consumption of residual heat and cold in heating and cooling	ktoe				
	Contribution of residual heat and cold in gross final consumption of heating and cooling	%				
	Gross final consumption of renewable energy in district heating and cooling	ktoe				
	Contribution of renewable energy from district heating and cooling to final gross consumption of heating and cooling	%				
	Gross final consumption of residual heat and cold in district heating and cooling	ktoe				
	Contribution of residual heat and cold in district heating and cooling in the final gross consumption of heating and cooling	%				
2	**Generation of electricity and heat from renewable energy in buildings (as defined in Article 2(1) of Directive 2010/31/EU; disaggregated data on energy produced, consumed and injected into the network by means of photovoltaic solar systems, solar thermal systems, biomass, heat pumps and geothermal systems, as well as other decentralised renewable energy systems) must be included**					
3	**Where appropriate, other national trajectories, including long-term or sector-based ones (the share of advanced biofuels produced from food crops, the share of renewable energy in district heating, as well as renewable energy produced by cities and energy communities as defined in Article 22 of (recast) Directive 2009/28/EC, proposed by COM(2016) 767**					
	Share of biofuels from food crops	%		5.60 %	5.18 %	3.93 %
	Advanced biofuel quota	%		0.82 %	0.95 %	1.80 %

3. Indicators related to emissions and absorption of GHG		Units	2015	2020	2025	2030
1	**GHG emissions by sector (ETS, Regulation on distribution of efforts and LULUCF)**	**teq.CO_2**	**335 809 458**	**327 442 938**	**266 342 791**	**226 737 050**
	ETS Emissions (2013 ETS areas)	teq.CO_2	139 751 465	131 713 529	93 274 704	82 039 183
	Regulation on the distribution of efforts (in the 2013 areas)	teq.CO_2	196 057 993	195 729 408	173 068 087	144 697 867
	LULUCF (counted in accordance with the requirements of EU law)	teq.CO_2	-42 007 067	-35 281 478	-32 520 218	-31 588 501
2	**GHG emissions by IPCC sector and by gas (when relevant, broken down into ETS and RRE)**	**teq.CO_2**				
	Transformation, primary energy and exchanges	teq.CO_2	16 796 815	17 682 662	16 593 642	15 763 988
	Agriculture	teq.CO_2	34 532 980	34 628 465	32 302 027	29 975 278
	Electricity generation	teq.CO_2	74 050 523	63 518 408	27 203 490	19 650 340
	Industry (combustion)	teq.CO_2	40 462 329	40 498 934	37 246 075	33 529 629
	Industry (processes)	teq.CO_2	21 036 000	21 509 481	22 026 062	22 428 912
	Residential	teq.CO_2	17 212 310	14 633 204	11 632 116	9 083 487
	Tertiary	teq.CO_2	10 923 001	11 924 742	11 667 694	10 348 859
	Transport	teq.CO_2	83 197 462	85 722 267	74 638 027	57 695 037
3	**Coal intensity of the general economy**	**teq.CO_2/GDP (EUR million)**	**313.63**	**267.66**	**199.69**	**159.52**
4	**Indicators related to CO_2 emissions**					
a	**Carbon intensity of electricity and steam production**	**teq.CO_2/MWh**	**0.26**	**0.22**	**0.09**	**0.06**
b	**Carbon intensity of final energy demand by sector**	**teq.CO_2/toe**				
	Industry	teq.CO2/toe	2.24	1.85	1.70	1.53
	Residential	teq.CO2/toe	1.15	1.08	0.92	0.78
	Tertiary	teq.CO2/toe	1.02	1.11	1.10	1.00
	Passenger transport	teq.CO2/toe	2.82	2.41	2.28	2.11
	Freight transport	teq.CO2/toe	IE	IE	IE	IE
5	**Parameters related to emissions other than CO_2**					
a	**Livestock**					
	Dairy cattle	1 000 head	848.7	816.2	797.7	779.3
	Non-dairy cattle	1 000 head	5 359.8	5 557.6	5 562.7	5 567.7
	Pigs	1 000 head	27 677.9	29 228.0	30 279.7	31 331.4
	Sheep	1 000 head	16 026.4	15 159.6	14 155.4	13 151.2
	Poultry	1 000 head	127 143.1	131 016.3	131 260.2	131 504.2
b	**Contributions of nitrogen resulting from the application of synthetic fertilisers**	**kt nitrogen**	**1 068**	**1 000**	**970**	**940**
c	**Contributions of nitrogen resulting from the application of manure**	**kt nitrogen**	**442**	**462**	**480**	**498**
d	**Nitrogen fixed by nitrogen-fixing crops**	**kt nitrogen**	**NE**	**NE**	**NE**	**NE**
e	**Nitrogen in crop residues that return to soil**	**kt nitrogen**	**120**	**123**	**126**	**129**
f	**Area of cultivated organic soils**	**hectares**	**NO**	**NO**	**NO**	**NO**
g	**Municipal solid waste (MSW) generation**	**t**	**21 158 000**	**21 754 011**	**20 786 549**	**19 819 088**
h	**Municipal solid waste (MSW) deposited in landfills**	**t**	**12 129 000**	**9 789 305.0**	**7 074 752.1**	**4 360 199.3**
i	**Proportion of CH_4 recovered from the total CH_4 generated in landfills**	**%**	**18.0 %**	***0.18***	***0.2***	***0.2***

Source: Ministry for Ecological Transition, 2019

A.7.3 Annex V MMR Table

CO_2

Submission Year	2019	Export to XML			
MS	ES				
Category (1,3)	Scenario (WEM, WAM, WOM)	CO2 (kt)	CO2 (kt)	CO2 (kt)	CO2 (kt)
		2016	**2020**	**2025**	**2030**
Total excluding LULUCF	WEM	**260.985,9**	**269.552,7**	**256.512,8**	**254.427,5**
Total including LULUCF	WEM	**219.781,1**	**233.868,0**	**223.598,0**	**222.452,6**
Total excluding LULUCF	WOM				
Total including LULUCF	WOM				
Total excluding LULUCF	WAM	**260.985,9**	**265.400,6**	**210.874,3**	**177.992,7**
Total including LULUCF	WAM	**216.965,3**	**223.573,4**	**170.728,9**	**141.584,9**

N_2O

Submission Year	2019				
MS	ES				
Category (1,3)	Scenario (WEM, WAM, WOM)	N2O (kt)	N2O (kt)	N2O (kt)	N2O (kt)
		2016	**2020**	**2025**	**2030**
Total excluding LULUCF	WEM	**55,1**	**56,3**	**56,2**	**56,5**
Total including LULUCF	WEM	**56,1**	**57,1**	**57,0**	**57,2**
Total excluding LULUCF	WOM				
Total including LULUCF	WOM				
Total excluding LULUCF	WAM	**55,1**	**56,4**	**53,9**	**52,3**
Total including LULUCF	WAM	**56,1**	**57,2**	**54,7**	**53,1**

CH_4

Submission Year	2019				
MS	ES				
Category (1,3)	Scenario (WEM, WAM, WOM)	CH4 (kt)	CH4 (kt)	CH4 (kt)	CH4 (kt)
		2016	**2020**	**2025**	**2030**
Total excluding LULUCF	WEM	**1.490,4**	**1.482,0**	**1.447,9**	**1.409,3**
Total including LULUCF	WEM	**1.496,9**	**1.488,5**	**1.454,4**	**1.415,8**
Total excluding LULUCF	WOM				
Total including LULUCF	WOM				
Total excluding LULUCF	WAM	**1.490,4**	**1.475,4**	**1.326,5**	**1.160,7**
Total including LULUCF	WAM	**1.496,9**	**1.481,9**	**1.333,1**	**1.167,2**

HFCs

Submission Year	2019				
MS	ES				
Category (1,3)	Scenario (WEM, WAM, WOM)	HFC (kt CO2e)	HFC (kt CO2e)	HFC (kt CO2e)	HFC (kt CO2e)
		2016	**2020**	**2025**	**2030**
Total excluding LULUCF	WEM	**9.713,6**	**8.007,1**	**5.873,9**	**3.740,7**
Total including LULUCF	WEM	**9.713,6**	**8.007,1**	**5.873,9**	**3.740,7**
Total excluding LULUCF	WOM				
Total including LULUCF	WOM				
Total excluding LULUCF	WAM	**9.713,6**	**8.007,1**	**5.873,9**	**3.740,7**
Total including LULUCF	WAM	**9.713,6**	**8.007,1**	**5.873,9**	**3.740,7**

PFCs

Submission Year	2019				
MS	ES				
Category (1,3)	Scenario (WEM, WAM, WOM)	PFC (kt CO2e)	PFC (kt CO2e)	PFC (kt CO2e)	PFC (kt CO2e)
		2016	2020	2025	2030
Total excluding LULUCF	WEM	92,0	97,8	101,4	103,6
Total including LULUCF	WEM	92,0	97,8	101,4	103,6
Total excluding LULUCF	WOM				
Total including LULUCF	WOM				
Total excluding LULUCF	WAM	92,0	97,8	101,4	103,6
Total including LULUCF	WAM	92,0	97,8	101,4	103,6

SF_6

Submission Year	2019				
MS	ES				
Category (1,3)	Scenario (WEM, WAM, WOM)	SF6 (kt CO2e)	SF6 (kt CO2e)	SF6 (kt CO2e)	SF6 (kt CO2e)
		2016	2020	2025	2030
Total excluding LULUCF	WEM	229,6	254,7	275,3	295,9
Total including LULUCF	WEM	229,6	254,7	275,3	295,9
Total excluding LULUCF	WOM				
Total including LULUCF	WOM				
Total excluding LULUCF	WAM	229,6	254,7	275,3	295,9
Total including LULUCF	WAM	229,6	254,7	275,3	295,9

GHG

Submission Year	2019				
MS	ES				
Category (1,3)	Scenario (WEM, WAM, WOM)	Total GHGs (ktCO2e)	Total GHGs (ktCO2e)	Total GHGs (ktCO2e)	Total GHGs (ktCO2e)
		2016	2020	2025	2030
Total excluding LULUCF	WEM	324.706,6	331.734,1	315.710,0	310.632,1
Total including LULUCF	WEM	283.957,6	296.452,6	283.189,8	279.043,6
Total excluding LULUCF	WOM				
Total including LULUCF	WOM				
Total excluding LULUCF	WAM	324.706,6	327.442,9	266.342,8	226.737,1
Total including LULUCF	WAM	281.141,8	286.018,9	226.591,8	190.715,6

ETS GHG

Submission Year	2019				
MS	ES				
Category (1,3)	Scenario (WEM, WAM, WOM)	Total ETS GHGs (ktCO2e)	Total ETS GHGs (ktCO2e)	Total ETS GHGs (ktCO2e)	Total ETS GHGs (ktCO2e)
		2016	2020	2025	2030
Total excluding LULUCF	WEM	126.234,3	129.091,8	114.209,2	113.166,8
Total including LULUCF	WEM	126.234,3	129.091,8	114.209,2	113.166,8
Total excluding LULUCF	WOM				
Total including LULUCF	WOM				
Total excluding LULUCF	WAM	126.234,3	131.713,5	93.274,7	82.039,2
Total including LULUCF	WAM	126.234,3	131.713,5	93.274,7	82.039,2

ESD GHG

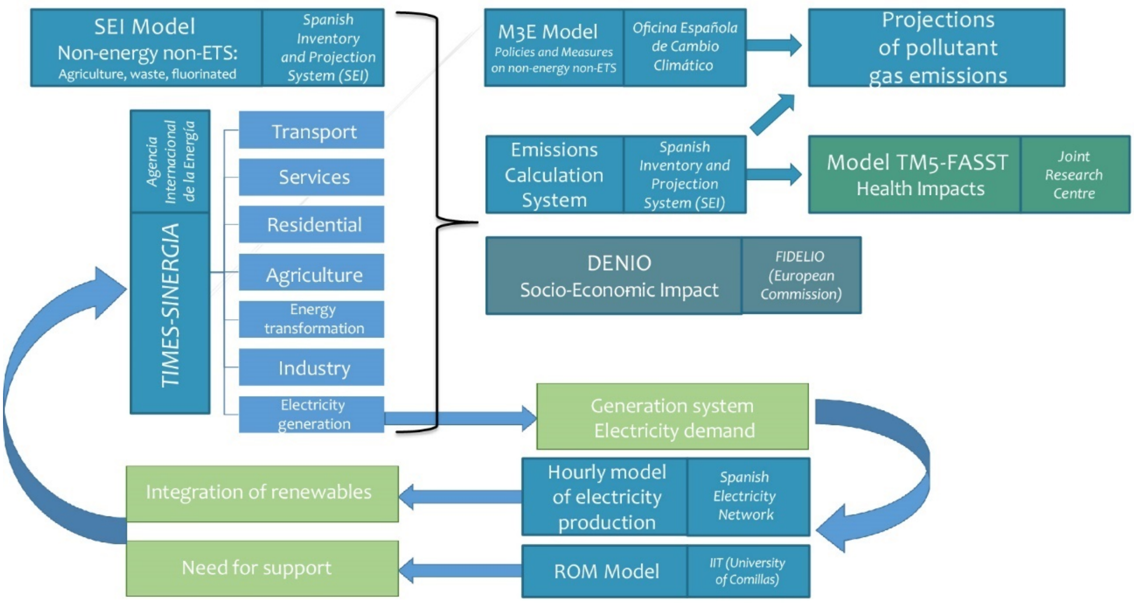
Submission Year	2019				
MS	ES				
Category (1,3)	Scenario (WEM, WAM, WOM)	Total ESD GHGs (ktCO2e)	Total ESD GHGs (ktCO2e)	Total ESD GHGs (ktCO2e)	Total ESD GHGs (ktCO2e)
		2016	2020	2025	2030
Total excluding LULUCF	WEM	198.472,2	202.642,4	201.500,8	197.465,3
Total including LULUCF	WEM	198.472,2	202.642,4	201.500,8	197.465,3
Total excluding LULUCF	WOM				
Total including LULUCF	WOM				
Total excluding LULUCF	WAM	198.472,2	195.729,4	173.068,1	144.697,9
Total including LULUCF	WAM	198.472,2	195.729,4	173.068,1	144.697,9

ANNEX B. MODELS USED IN THE INECP

B.1. MODELLING OF THE ENERGY SYSTEM

The modelling of the energy system for INECP 2021-2030 was completed with the TIMES-SINERGIA (Sistema Integrado para el Estudio de la Energía, Integrated System for the Study of Energy) tool of the Directorate-General for Energy Policy and Mines. In addition, higher order models were used to determine the effects of a high penetration of renewable energies in the electricity system, in order to make the results compatible with an adequate security of supply. The other models used, which will be described later in this section, are the REE (Red Eléctrica de España - Spain's power transmission company) model and the ROM (Reliability and Operation Model for Renewable Energy Sources) of the Institute for Research in Technology of the Comillas Pontifical University (Universidad Pontificia de Comillas).

Figure B.1 Method



Source: Basque Centre for Climate Change, 2019.

While TIMES-SINERGIA covers the entire energy system, the other complementary models are specifically dedicated to the representation of the electrical system. In addition, they include specific features of the electricity system that are not captured by the TIMES-SINERGIA model, such as the inclusion of scheduling periods for power generation and the incorporation of technical restrictions of the system's generation units.

The joint use of all the models makes it possible to assess backup needs, energy exchange at interconnections, as well as other technical issues resulting from the integration of high inputs of renewable energies into the electricity system, such as discharges, or adjustments in conventional combined-cycle generation. The figure represents the bidirectional interaction between the TIMES-SINERGIA energy system model and the REE and ROM models. According to the results of the generation system in terms of installed capacity and generation of each technology, together with the electricity demand outputs obtained in the TIMES-SINERGIA model, they were evaluated by the REE and ROM models. Subsequently, the outputs of these models have determined the operating requirements of the conventional and renewable technology generation systems with these higher order models, subsequently integrating the results into TIMES-SINERGIA. With this exercise, the technical restrictions considered in the specific electricity generation models are incorporated into the general model of the energy system.

B.1.1 TIMES-SINERGIA DGPEM Model

The Integrated MARKAL-EFOM System (TIMES) tool was used in drafting the INECP to analyse the energy system and its outlook. TIMES was developed by the International Energy Agency within the framework of the ETSAP (Energy Technology Systems Analysis Program) for the development of energy and environmental analyses.

TIMES has been used to model the energy system in more than 60 countries and is a tool widely used in Europe, for example, in Italy, Portugal, Finland and Norway.

In the case of Spain, the TIMES-Spain model was developed by the Energy, Environment and Technology Research Centre (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas - CIEMAT) taking 2005 as the base year.

The Directorate-General for Energy Policy and Mines (DGPEM), which reports to the State Secretariat for Energy of MITECO, has carried out the necessary work to use TIMES as a tool for energy forecasting and analysis in the preparation of the INECP, adapting TIMES-Spain. The new model was named TIMES-SINERGIA (Integrated System for the Study of Energy).

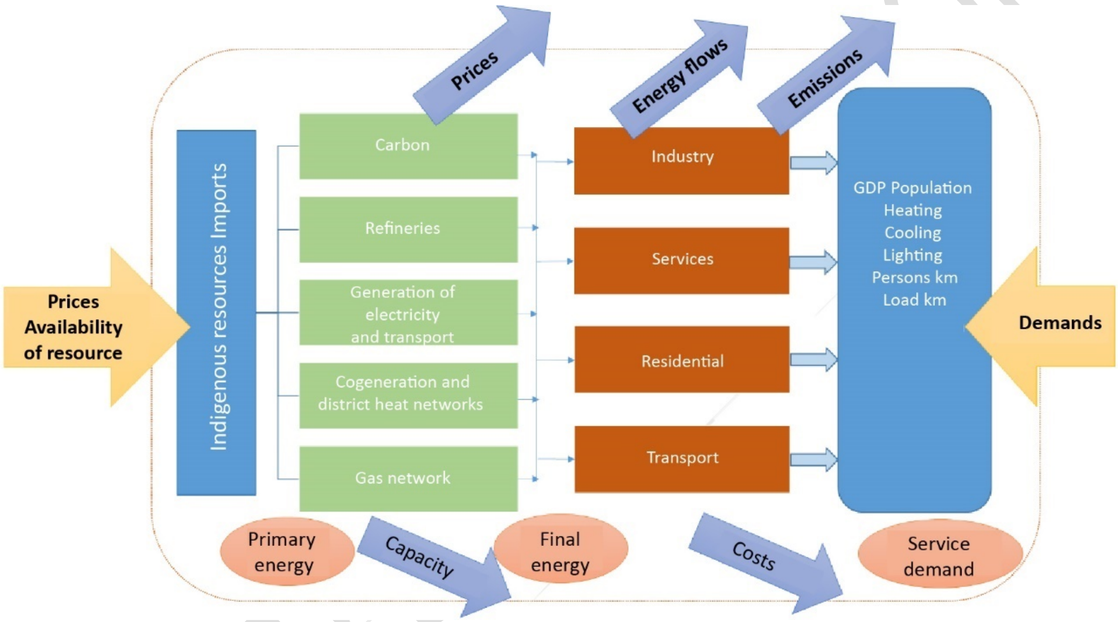
TIMES is a bottom-up mathematical model generator. This means that the model starts from each of the components of the energy system and then obtains the data at an aggregated level. The TIMES model generator combines two complementary approaches, one technical and the other economic. It is based on the linear optimisation of the energy system, seeking a solution under the minimum cost principle.

It has a detailed characterisation of energy technologies and demands for energy services such as passenger-km for the transport sector, or production in tonnes for the industrial sectors. For the different scenarios presented in the model, TIMES covers the demand for energy services through a combination of operational and investment decisions, minimising the cost of the energy system over the time frame analysed.

Some of the most relevant model results are the consumption and production of energy goods and services, flows, and prices and costs of energy goods. It also provides GHG emissions and air pollutants and is therefore suitable not only for the study of the energy system, but also in an integrated manner for the analysis of environmental policies.

The figure shows the inputs and outputs of the TIMES-SINERGIA model, where it can be seen that based on parameters of service demand, energy prices and resource availability, the model determines the capacity to be installed, energy consumed, emissions and process prices.

Figure B.2 Diagram of TIMES-SINERGIA inputs and outputs



Source: International Energy Agency

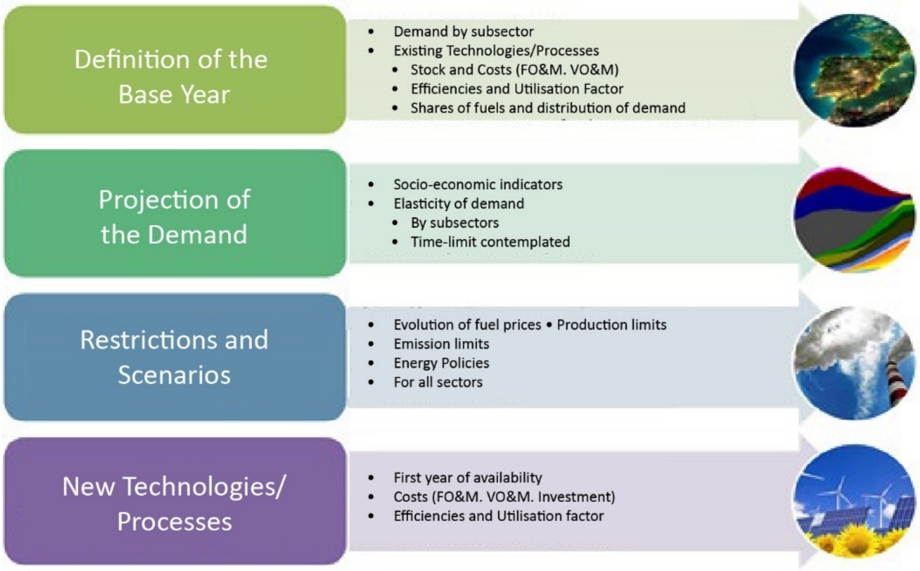
1 TIMES-SINERGIA Model Structure

The model uses a detailed database that enables the current and future energy system to be defined, by modelling the different sectors related to energy consumption. In this way, the national energy structure is characterised through:

- Definition of the Base Year. It includes all the variables, energy products, as well as its energy flows for the year 2014. In this way, real historical data characterising the national energy system are entered. This definition includes data on primary consumption, final consumption and transformation sector. Likewise, all existing technologies with all their characteristics, of each and every one of the economic sectors, generation of electricity, industry, transport, residential, services, agriculture and other, are modelled.
- Demand Projections. In addition, the future demands for energy services, prices and products of the model's input variables are included. These data allow future scenarios to be implemented for subsequent energy analysis.
- The parameters that characterise both existing and future technologies are their efficiency; the utilisation factor, which reflects the average hours of use of each technology compared to the annual total; the existing system; the useful life; and the investment, operating and maintenance costs.
- New technologies and processes. The model also considers the different alternatives to meet future demands. To do this, an extensive database, including a portfolio of future technologies, is available. These new technologies will enter the energy system by replacing the current ones at the end of their useful life, or through the implementation of other environmental or technical assumptions for their replacement.
- Restrictions. They enable the effect of policies and measures, environmental or physical restrictions, as well as other determinants in the projections to be incorporated into the model.
- Scenarios. They enable different snapshots of the energy system to be represented for subsequent analysis. Through the study of different scenarios, it will be possible to analyse different alternatives for future development and evaluate the influence of the different energy policies adopted.

A diagram with the TIMES-SINERGIA data structure is shown below.

Figure B.3 TIMES-SINERGIA data structure



Source: International Energy Agency

In the following figure, the different parameters that characterise the technologies are shown.

Figure B.4 Parameters that characterise the technologies in TIMES-SINERGIA

Source: International Energy Agency

In TIMES-SINERGIA two types of scenarios were considered: the reference energy system or Baseline Scenario and the Target Scenario. The Baseline Scenario considers the evolution of the national energy sector in the event that the policies and measures proposed in the INECP are not implemented. The Target Scenario poses the same evolution, but for the case in which the policies and measures proposed to achieve the targets are complied with.

2 General modelling

Spatial and temporal resolution in TIMES-SINERGIA

The TIMES-SINERGIA model consists of a single region, corresponding to Spain. The time frame analysed starts from 2014, defined as the base year. In addition, historical data from 2015 are used to calibrate the model. Additionally, the results for 2017 are included and then, in periods of 5 years, the years 2020 to 2040.

TIMES-SINERGIA reflects the variability of the demands throughout the year and the day by means of time slices. With this, it is possible to simulate the form of electricity demand, as well as the production curves of renewable energies. These time periods correspond to the different seasons of the year (spring-R, summer-S, autumn-F, winter-W), subdividing them into sections: day-D, night-N, peak-P (coinciding with the hours of greatest electricity demand in each season) and trough, or valley-V (including the hours with the lowest electricity demand).

In this way, the time structure of each year is divided into sixteen time slots; for example, one would be summer and night. These time divisions are used both to model the demands of energy technologies and to represent the generation profiles.

Table B.1 Time periods. Annual distribution

Stations	No of days	Fraction of the year	DD/MM
R	92	0.25	21/03-20/06
S	92	0.25	21/06-20/09
F	91	0.25	21/09-20/12
W	90	0.25	21/12-20/03

Source: International Energy Agency

Table B.2 Time periods. Daily distribution of the number of hours

	D	P	N	V
R	10	3	5	6
S	10	3	5	6
F	10	3	5	6
W	10	3	5	6

Source: International Energy Agency

capacity according to its useful life. Thus, the **Table B.3 Time Periods. Time slots**

	D	P	N	V
R	09:00-11:00 15:00-21:00	12:00-14:00	22:00-00:00 07:00-08:00	01:00-06:00
S	09:00-11:00 15:00-21:00	12:00-14:00	22:00-00:00 07:00-08:00	01:00-06:00
F	09:00-18:00	19:00-21:00	22:00-00:00 07:00-08:00	01:00-06:00
W	09:00-18:00	19:00-21:00	22:00-00:00 07:00-08:00	01:00-06:00

Source: International Energy Agency

Estimated emissions

The emissions of the energy sectors, both derived from combustion (CRF 1A activity) and fugitive emissions (CRF 1B activity), as well as emissions arising from industrial processes (CRF 2A, B and C activities) were carried out using the activity variables projected as a result of the scenarios generated by the TIMES-SINERGIA model.

Complementarily, emissions from the rest of the non-energy sectors (agriculture (CRF 3), waste (CRF 5) and product use (CRF 2D-2H)) and emissions and absorptions linked to land use, changes in land use and forests (LULUCF-CRF 4) were projected, on a case-by-case basis, according to national forecasts of the main activity variables representative of each sector.

Emissions and, where appropriate, absorptions were estimated for each of the GHGs regarding the projections of the activity variables, by applying calculation methodologies similar to those implemented in the National Emissions Inventory, consistent with international methodological guidelines. The 2018 edition of the National Greenhouse Gas Emissions Inventory, corresponding to the 1990-2016 series, was used as a reference for the calculation of projected emissions.

The estimates of projected emissions were made jointly and coherently both for GHGs (CO_2, CH_4, N_2O and fluorinated gases) and for emissions of associated atmospheric pollutants (NH_3, COVNM, $PM_{2,5}$, SOx, NOx and CO), which will be included in the Atmospheric Pollution Monitoring Programme (Programa de Control de la Contaminación Atmosférica).

The reference year of the projected series is the reported year, 2016. The geographical coverage used was unique for the entire national territory, assuming characteristics and average parameters. Historical data from the National Emissions Inventory (1990-2016) were used for the analysis of emission trends and emission factors (direct and implicit). The time frame projected was 2017-2040 with annual time periods. As reference methodological guidelines, the 2006 IPCC Guidelines and the EMEP/EEA 2016 Methodological Guidelines were used, as in the National Emissions Inventory.

Baseline data and macroeconomic assumptions

The database on which the TIMES-SINERGIA model is based draws on a variety of sources. For historical data, in the case of energy variables, the energy balances published by Eurostat are used as a starting point, which in turn are compiled from data provided by the national statistical system. In the data on historical energy production and consumption in the industrial sector, statistics from the General State Administration, available in the Spanish Emissions Inventory System, were used.

In addition, in order to design future scenarios, projections are made of the demands for end-use energy services. To this end, macroeconomic variables such as GDP, GDP per capita or number of households are used to determine the elasticity or the relationship of energy service demand with these macroeconomic variables. Finally, using the GDP evolution projections, the input values of the model are determined for the demands for energy services in future time periods, considering both the evolution of macroeconomic variables and their elasticities with demand.

The prices of CO_2 emission allowances subject to the ETS[67] system as well as the main energy vectors (coal, gas and crude oil) are those recommended by the European Commission for the development of the Plans.

3 Sectoral modelling

By aggregating their demands, TIMES represents each of the energy consuming sectors in order to determine their primary and final energy needs and characterise the electricity generation demands and production needs of the energy transformation sector.

Residential sector, services and other sectors

The residential, services and ‘other’ sectors include the coverage of the demands of the residential sector, which includes energy needs in the domestic sphere; and the services and ‘other’ sectors, which include the demands for energy services originating in buildings with public and private economic activity (commercial, health, public, workplaces, among others), as well as the ‘other’ sector, which represents the sectors of economic activity not included in the rest of the TIMES-SINERGIA breakdowns, modelled in an aggregate manner.

The residential and services sectors break down their demands for energy services according to final energy uses, including the categories of heating, cooling, lighting, hot water, kitchens and diverse electrical and electronic equipment (white goods, brown goods and others specific to the use of each building). In addition, the demands for public lighting are included.

For the residential sector, three types of housing are included: single-family housing, multi-family housing with collective heating and/or domestic hot water systems and multi-family housing with individual heating and/or domestic hot water systems. A distinction is also made between existing and newly built or rehabilitated housing. This reflects the differences in energy consumption patterns for the different types of buildings considered, as well as the diversity of technologies installed in each type.

In the case of the service sector, no distinction is made according to the type or use of building. The modelled technologies are analogous to those of the residential sector, although on a larger scale.

The modelled technologies in the residential and services sectors are detailed below, classifying them according to the coverage of the corresponding energy service:

a) **Heating.** Stoves, convectors, fireplaces, solar panels and heat pumps are included. In turn, these technologies are divided according to the fuel or energy source used (coal, propane, gas oil, gas, solar, electricity, geothermal, aerothermal, hydrothermal or renewable heat generation).

b) **Cooling.** Aerothermal, geothermal and hydrothermal heat pumps, absorption machines and solar cooling were modelled.

c) **DHW (Domestic Hot Water).** The model includes mixed boilers, water heaters, thermos flasks and heat pumps. There are different technologies of each type according to the fuel or energy source used (coal, propane, gas oil, gas, solar, electricity, geothermal, aerothermal, hydrothermal or renewable heat generation).

[67] ETS: Emission Trading Scheme.

d) **Lighting in buildings and public lighting.** Incandescent, halogen, LED and fluorescent lamps are used.

e) **Kitchens.** In the residential sector, it includes technologies that run on different fuels (wood, coal, gas, propane or butane and electricity). In the case of the service sector, a generic technology called 'kitchen equipment' is included, which includes a variety of equipment used in service sector kitchens such as the kitchens themselves, but also ovens, steamers, hot tables, among others.

In addition, some of the technologies mentioned above simultaneously cover several demands for energy services. This is the case for gas boilers that are used for both heating and domestic hot water demands; for heat pumps, which can be used for heating and cooling, and which could also meet domestic hot water demands.

Each of the technologies indicated is characterised by a series of parameters that are detailed below. These parameters configure their energy performance:

- **Efficiency:** its evolution over time is defined by means of learning curves in such a way that the efficiency improvement paths are studied throughout the periods considered.
- The **availability factor**, given by a ratio that reflects the average hours of use of each technology compared to the annual total.
- The **existing stock** that characterises the number of units of each technology.
- The **useful life** of each technology.
- The **costs.** It includes both **investment** costs for new technologies and **operating and maintenance** costs for new and existing technologies.

In addition to the above, in the residential sector the equipment included in the white goods and brown goods categories has been modelled in an aggregate manner. Similarly, this approach was applied for other uses associated with building use in the services sector.

The initial data and assumptions for the residential sector, services and other sectors with the greatest influence on the results of the model are derived from the change in the number of households, both existing and newly built; or the building floor area in the services sector, whether existing, new or renovated.

Transport sector

The transport sector is an energy-consuming sector that brings together the demands for mobility energy services, both for people and goods. These service demands are expressed in millions of passenger-km or millions of tonne-km for the different modes of transport: road, rail, sea and air.

Within the TIMES-SINERGIA model, different categories of vehicles can be distinguished to meet these demands for energy services. At the same time, within these categories, each vehicle is differentiated according to the type of fuel it uses, these being gas, electricity, diesel, gasoline, biofuels, and compressed or liquefied natural gas. In particular, the mixture of bio-fuels with traditional fossil fuels has been considered.

The different types of vehicles according to the demand for the energy services they satisfy, including both existing and future technologies, are detailed below:

a) **Road transport.** This includes the various types of transport of goods and persons:

- **Passenger cars.** Demand is divided into short and long distance.
- **Motorcycles and quadricycles.** It is assumed that they are primarily involved in short-distance demand.
- **Buses.** Urban and interurban buses were modelled.
- **Heavy load (lorries).** This includes vehicles of more than 3.5 tonnes that cover the demand for transporting goods.
- **Light load (vans).** This includes vehicles with less than 3.5 tonnes of load used primarily for the transport of goods over short distances (urban environment).

b) Transport by rail. This includes vehicles running on rails powered by electricity or diesel.

- **Passenger trains.** This includes long and medium-distance trains, as well as commuter trains.
- **Freight trains.**
- **Metros and trams.** All the vehicles are electric and satisfy the demand for urban transport.

c) **Transport in aviation and navigation.** The national and international aviation and navigation demands are modelled in an aggregated manner. In addition, energy in marine and aviation bunkers is included.

The parameters that characterise the functioning of the transport sector technologies are:

- **Efficiency:** its evolution over time is defined by means of learning curves in such a way that the efficiency improvement paths are studied throughout the periods considered.
- The **availability factor**, given by a ratio that reflects the average hours of use of each technology compared to the annual total.
- The **activity factor**, which indicates the vehicle occupancy rate, in terms of tonnes for goods or passenger vehicles.
- The **existing stock** that characterises the number of units of each technology.
- The **useful life** of each technology.
- The **costs.** These include both **investment** costs for new technologies and **operation and maintenance** costs for new and existing technologies.

The data and starting assumptions of the transport sector that most influence the results of the model are the penetration of new technologies, especially those that use alternative fuels, as well as the biofuels mix in the transport sector.

Industrial Sector

In this sector, end-use energy demands are determined from the production in physical units (tonnes) of industrial products. To this end, it was divided into relevant subsectors in terms of consumption, for which both the technologies used in industrial processes and the demands related to each of these processes are included, whether they are heat or electricity demands.

Industrial production is an input to the model, determined by the evolution of GDP. With this macroeconomic parameter and the elasticity that relates it to industrial production, sectoral production is determined.

The sectors considered for individual modelling are:

- iron and steel;
- aluminium, copper and other non-ferrous metals;
- ammonia, chlorine and other chemicals;
- cement, lime, glass and other non-metallic minerals;
- and paper.

Additionally, for the rest of the industrial sectors, an aggregate modelling is completed, including the economic activities of the industrial sector not included in the previous classifications.

Cogeneration has been included in this sector, providing end-use energy for both thermal and electricity uses. Different technologies are included depending on the energy source they use, including coal, refinery gas, fuel oil, natural gas, biomass, waste and biogas.

Each of the technologies indicated is characterised by a series of parameters that are detailed below.

- **Production ratios:** indicate the relationship between the production of physical units and energy consumed.
- **Existing fleet.**
- **Percentages of fuel consumption:** are used in the case of technologies that can consume different fuels.
- **Investment, operating and maintenance costs.**
- **Useful life.**
- **Electrical and thermal efficiency.**
- **Coefficient of distribution between the energy discharged into the grid and the heat produced** for cogeneration.
- The **availability factor**, given by a ratio that reflects the average hours of use of each technology compared to the annual total.

The most relevant initial data and assumptions for the industrial sector are related to the evolution of production and the industrial processes used.

Agricultural sector

Includes agriculture, livestock, forestry and fishing. The sector is included in the model in aggregate form, characterised according to its energy consumption profile for the different fuels and energy used. Only their behaviour as energy consumers is modelled in these sectors.

Primary energy, transformations and exchanges sector

The primary energy, transformations and exchanges sector, unlike the sectors described above, represents the energy transformations necessary to convert primary energy into final energy; i.e., it represents a part of the energy transformation sector, excluding the electricity generation sector which is modelled in detail and described under the next heading. The sector comprises primary production, i.e., the extraction of fuels, crude oil, natural gas and coal (coal, anthracite and lignite), as well as potential for the generation of national renewable sources: biomass, waste, waste heat, hydroelectric power, wind, solar and geothermal energy.

In addition to this, account is taken of industries associated with energy transformation or secondary energy production, which includes coke ovens, refineries, biofuel production and the transmission of electrical energy.

In addition, in order to supply primary energy, the system considers the supply through the importing of fuels. Similarly, exports by region are included.

Electricity generation sector

The model is based on the generation system existing in base year 2014, and it satisfies the electricity demand of the other sectors, seeking the economic optimum of the global energy system in the time frame considered. In order to do so, it installs new generation capacity where necessary, taking into account all the costs and operating characteristics related to the different technologies considered.

The generating technologies, both existing and new, were modelled, by defining their characteristics: the operating profile, maximum annual operating hours, efficiency, investment costs, operating and maintenance costs, useful life of the technologies, fuel costs, fuel distribution by technology, consumption in ancillary systems, emissions costs, and their evolution in the time frame considered.

It should be noted that in TIMES-SINERGIA the electricity system is modelled as a single node system, including non-mainland territories, although account is taken of the losses inherent in the transport and distribution network, as well as the different cross-border connections and the expected increase in their capacity.

Finally, it is necessary to establish a series of contour restrictions, mainly related to the characteristics and operation of generation technologies, in an attempt to approximate the behaviour of the model to reality.

A series of generation technologies existing in the base year (2014) were considered, as well as a series of new technologies - those that came into service from 2014.

Existing technologies considered are classified into:

- Conventional generation facilities:
  - nuclear;
  - coal;
  - combined gas cycle;

- fuel/gas (non-peninsular territories);
- municipal solid waste (MSW) (half of the generation of this technology is considered renewable, due to the biodegradable fraction of MSW).

* Renewable energy generation and pumping installations:
  - biomass;
  - biogas;
  - solar thermoelectric;
  - solar photovoltaic;
  - wind;
  - Hydroelectric power
  - hydraulic pumping systems;
  - municipal solid waste (MSW) (half of the generation of this technology is considered renewable, due to the biodegradable fraction of MSW).

In relation to the new technologies considered in the model, it has been assumed that these will be solely and exclusively renewable energy generation and storage facilities. In addition to new existing-technology facilities (commissioned after 2014), the following technologies, not present in the base year generation system, were included:

* New generation technologies with renewable energies and storage:
  - solar thermoelectric with more than 9 hours of storage;
  - batteries with 2 hours of storage;
  - marine energy technologies;
  - geothermal energy.

The parameters that characterise the electricity-generation technologies are:

<u>Operating profiles</u>

The different generation technologies have a defined operating profile through the availability factor. This is expressed as a percentage and relates the hours when the technology is available during a period to the total hours of that period.

In TIMES-SINERGIA, the availability factor indicated for each technology corresponds to an upper limit referring to the maximum operating hours of each technology during the period considered; therefore, it refers more to a maximum usage factor thereof, rather than availability.

In TIMES-SINERGIA the following types of availability factors are defined:

* Annual availability factor: this annual factor, expressed as a percentage, indicates the relationship between the maximum operating hours of the technology in a year and the total annual hours.
* Availability factor per period (time slice): this factor per period, also expressed as a percentage, indicates the relationship between the maximum operating hours of the technology in a given period and the total hours of the same period.

The definition of availability factors by time period is especially relevant in the case of renewable energy generation technologies, which will have greater or lesser availability depending on the availability of the renewable resource they use as an energy source. Thus, there will be technologies that are less available at times when electricity demand is high, and others, on the other hand, where their greater availability coincides with peak demand hours, depending on the season of the year and the period considered.

In the case of conventional generation technologies, availability factors per period are usually constant; in this case they provide information on the hours when the technology ceases to be available due to maintenance activities, technical restrictions or other causes unrelated to the availability of the resource.

Efficiency

The efficiency data of thermal generation installations, both conventional and renewable, were obtained from the data reported to Eurostat, and are considered constant over the entire time frame. No consideration is given to possible declines in performance over the course of the project. In technologies where more than one fuel is consumed, an efficiency is indicated for each fuel.

For new technologies not present in the base year generation system, the efficiencies provided by the Joint Research Centre (JRC) were considered.

In the case of renewable energy generation technologies (solar photovoltaic, wind, hydroelectric power except pumping and sea energy) an efficiency equal to 100 % was considered.

Investment, operating and maintenance costs

Another parameter that defines generation technologies is cost, which, in turn, is divided into investment costs (only for new installations), fixed operation and maintenance costs and variable operating and maintenance costs, as well as their variation over the time frame considered. These costs do not include costs associated with taxes, tariffs, fuels, etc.

Useful life

The useful life considered for renewable energy generation installations is that established in Order 1045/2014 of 16 June 2014, which approves the remuneration parameters of standard installations applicable to certain installations producing electrical energy from renewable energy sources, cogeneration and waste, with the following exceptions:

- a useful life of 25 years is considered for the new installed wind capacity;
- in the case of hydroelectric facilities, the extension of the useful life over the entire time frame is considered.

The following criteria were taken into consideration for non-renewable technology installations:

- Nuclear: the Baseline Scenario considers the extension of the useful life of these power plants over the entire time frame considered. The Target Scenario considers an orderly and progressive closure of the installed capacity of this technology.

- Coal: coal-fired power plants that have completed the necessary work to bring them into line with European emission standards by 2020 (around 4.53 GW) will continue to operate until 2030.
- Combined gas cycle: a useful life of 40 years is considered.
- Fuel/gas (non-peninsular territories): It is considered that the installed capacity of the fuel/gas power plants in 2014 will be halved by 2030.

In relation to the useful life and decrease in the generation capacity of the different technologies present in the generation system in the base year (2014), in order to establish the closure of the installations of the aforementioned generation system, the date of their commissioning was taken into account to reflect a decrease in capacity in line with their useful life. Thus, the capacity of the different existing technologies considered will be progressively reduced (according to their commissioning), and are replaced, if necessary, by the capacity to generate new technologies available in the system from 2014 onwards.

Consumption in generation

The consumptions in generation represent the ancillary consumptions of the different technologies. These were introduced in the TIMES-SINERGIA model as a percentage of the total electrical energy produced by each type of technology.

Transmission and distribution network losses

As mentioned above, the model simplifies the electricity system grid, considering it as a single node, although the efficiencies associated with this grid are established, making it possible to model the existing losses in the transmission and distribution of electricity in high, medium and low voltage grids, such as the losses associated with the transformation processes from high to medium voltage and from medium to low voltage. These losses are modelled with efficiency coefficients associated with high voltage (0.989), medium voltage (0.974) and low voltage (0.916).

Interconnections

In TIMES-SINERGIA, the following considerations were taken into account to model the interconnections:

- Interconnections with Morocco and Andorra: a constant net export balance per time period is considered, calculated as the average of the real values for the years 2014, 2015, 2016 and 2017.
- Interconnections with Portugal and France: both import and export capacity with these countries was considered jointly. With regard to interconnection capacity with France, it should be noted that the projected increases in this capacity were taken into account, reaching 5 000 MW in 2025 and 8 000 MW in 2030.

Renewable energy technology penetration

A maximum limit is established on the input of new generation power corresponding to photovoltaic and wind technologies during the 2020-2030 period.

Coupled thermal generation

A minimum of constant thermal generation provided by all nuclear, coal and combined-cycle power plants is considered. In addition, part of this minimum will correspond to the sum of combined-cycle and coal production, of which another part will be provided exclusively by combined-cycle power plants.

Calculating availability factors

The availability factors, both annual and per time period, were calculated for existing renewable technologies, from actual hourly production data for each technology. The availability factors for 2014 were obtained from the actual hourly production data for the aforementioned year, while for subsequent years, an average for the years 2014, 2015, 2016 and 2017 is assumed, and in the case of water technology, the data for 2015 is assumed, which is considered a year close to an average hydrological year.

In hydroelectric installations with more than 10 MW of power and in pumping installations, these factors for periods were increased with the aim of giving the different generation systems greater capacity to adapt these technologies in subsequent years.

For the rest of the technologies, different annual APIs were considered, adapted to the real availability of each technology arising from stoppages due to recharging, maintenance, unscheduled unavailability, etc.

Repowering

It is considered that the capacity of wind, solar photovoltaic, solar thermoelectric, biomass, biogas and urban solid waste technologies that reach the end of their useful life will be repowered to a greater or lesser degree depending on the technologies.

B.1.2 Red Eléctrica de España Model

The simulations use as a base assumption a market of perfect competition in electricity generation and, therefore, do not include the possible strategies of the generators to maximise their profits. The offer of each generator will be the variable cost of its generation.

The optimal generation dispatch is obtained by minimising the variable cost of generation on condition that the electricity demand is supplied in all countries and throughout the time period analysed.

The model used considers variable generation costs based on a forecast of fuel prices, estimated operating and maintenance costs for each technology and CO_2 emission costs. Fixed generation costs, costs of dismantling generator sets currently in service and not considered in the scenario to be evaluated, possible costs of extending the useful life of generator sets or other factors (tariffs, taxes, etc.) that may form part of the generation's supply strategy are not considered. Renewable generation is considered in the zero-variable cost model.

A simplified system model is used in which the different modelled systems (price zones) are represented as a network of nodes interconnected by the commercial exchange capacity available to the market (NTC - Net Transfer Capacity) according to the physical interconnections that exist between each of them. The model uses a fixed value of commercial exchange capacity between the modelled systems, without considering the exchange capacity variations that would correspond to different operating situations or reductions in their value due to unavailability of the transmission network or other circumstances. Within each price zone, the analysis carried out considers a single node, i.e., no losses or possible generation limitations due to elements of the internal network of each system are considered.

The model individually considers the operating parameters of each thermal generation unit, its availability and failure rates. Hydroelectric generation is modelled consistently with historical production series and wind; photovoltaic and thermosolar generation, using primary resource climatic historical series.

In each scenario, a complete simulation of the generation dispatch of the European system modelled during each hour of the year was carried out, respecting all group restrictions (start-up restrictions, stoppage restrictions, loading and unloading times, etc.) while minimising the total variable cost.

As a result, the marginal cost values and the exchange balance values resulting from the total variable cost minimisation process in the set modelled, respecting the established exchange capacity values, are obtained, with a detailed schedule over a year. Cogeneration is considered in the model, as is renewable generation, with zero variable cost, which gives them priority for dispatch over other technologies.

It is very important to stress that cost results should not be interpreted as prices and energy exchange results only consider the marginal cost difference between systems.

In the simulations carried out for generation dispatch, a restriction of 5 500 MW was implemented for all coupled thermal generation in the Iberian Peninsula.

The simulation results in renewable generation values and indicators on the percentage of renewables (RES) in electricity generation and electricity demand in the Spanish mainland system. In addition to the participation value of renewable generation in the electricity production mix, the study calculated the estimated participation values of renewable generation in the final energy in the Spanish mainland system.

B.1.3 ROM Model of the IIT of the University of Comillas

The ROM[68] model makes it possible to calculate the technical and economic impact of the operation of the electricity system, including the impact of the generation of variable origin and other types of technologies (active demand management, electric vehicles, solar thermal generation), also considering system reliability criteria. The ROM model is accredited and has been used and validated in different national and international projects.

This is a daily programming model that includes detailed operating restrictions, such as technical minima, up and down ramps and minimum operating and downtime of the thermal generating sets.

[68] https://www.iit.comillas.edu/oferta-tecnologica/rom

The execution of the simulations considers a chronological execution to evaluate each day of the year, considering 24 hours of the day. The model considers the scheduling profile for renewable generation based on historical series of the 2012-2016 period published by REE.

The calculation of additional backup power is based on the driest hydrological scenario considered. This support ensures that demand is met at all times and that there is sufficient operating reserve to cope with unexpected changes in demand or generation.

Decisions beyond this daily scope, such as the management of the weekly pumping operation, are made internally in the model using heuristic criteria. The annual management of hydroelectric power plants is decided by models higher in the hierarchy: for example, a hydrothermal coordination model that determines weekly set points based on historical data of cumulative water flows[69].

[69] S. Cerisola, J.M. Latorre, A. Ramos. Stochastic dual dynamic programming applied to nonconvex hydrothermal models. European Journal of Operational Research. vol. 218, no. 3, pp. 687-697, May 2012.

B.2 NON-ENERGY EMISSION MODELS

B.2.1. NON-ENERGY SECTOR PROJECTIONS

1. Introduction

As a complement to the modelling of the energy system for the INECP 2021-2030, carried out with the TIMES-SINERGIA model (see Annex I), the emissions of the rest of the non-energy sectors and the emissions and absorptions of the LULUCF sector were projected, on a case-by-case basis, according to national forecasts of the main activity variables representative of each sector.

On the projections of the activity variables, emissions and, where appropriate, absorptions were estimated for each of the GHGs by applying calculation methodologies consistent with those implemented in the National Emissions Inventory (2006 IPCC Guidelines and EMEP/EEA 2016 Methodological Guidelines). The 2018 edition of the National Greenhouse Gas Emissions Inventory, corresponding to the 1990-2016 series, was used as a reference for the calculation of projected emissions.

The reference year of the projected series is the year reported, 2016. The geographical coverage used was unique for the entire national territory, assuming characteristics and average parameters. Historical data from the National Emissions Inventory (1990-2016) were used for the analysis of emission trends and emission factors (direct and implicit). The time frame projected was 2017-2040 with annual time periods.

The estimates of projected emissions were made jointly and coherently both for GHGs (CO_2, CH_4, N_2O and fluorinated gases) and for emissions of associated atmospheric pollutants (NH_3, COVNM, $PM_{2,5}$, SOx, NOx and CO), which will be included in the Atmospheric Pollution Monitoring Programme (Programa de Control de la Contaminación Atmosférica).

The following is a brief description of the main features of the systems for calculating emission projections for the most relevant non-energy sectors: agriculture, waste, product use and land use, land-use change and forestry (LULUCF).

2. Agricultural sector projections

The estimation of projected emissions from the agriculture sector was carried out in a manner consistent with the calculation system applied in the 2018 edition of the National Greenhouse Gas Emissions Inventory, corresponding to the 1990-2016 series and based on the 2006 IPCC Methodological Guides using a level 2 methodological approach based on country-specific data. The reference year of the projected series is the reported year, 2016.

The two fundamental sets of data entry into the system that were taken into account in the projections are the livestock population and the consumption of inorganic fertilisers on fertilised cultivated area.

Forecasts of the evolution of the livestock population for beef, dairy cattle, sheep, pigs (white and Iberian), poultry, goats and horses for the projected period were provided by the Ministry of Agriculture, Fisheries and Food, based on historical data and market forecasts of livestock production.

For each livestock population, in addition to the census data, parameters relating to enteric fermentation and the country's own manure management were taken into account for the estimation of projected emissions in a manner consistent with the National Emissions Inventory. These data are based on zootechnical documents with specific data for Spain for each productive species and current data and forecasts on manure management systems. These calculations are carried out in a coordinated and consistent manner with the emissions estimate derived from the application of manure to field as an organic fertiliser (CRF 3Da2a sector), or emissions arising from grazing activities (CRF 3Da3 activity).

To estimate projected emissions derived from crop management (CRF 3C, D, F, G and H activities), both the total cultivated areas (including rice) and the total quantity and type of inorganic fertilisers applied to the field as fertilisers were taken into account. These practices also took into account the current degree of implementation of available technical improvements and their foreseeable future evolution. The arable area used is consistent with inventory data in the latest edition of the National Emissions Inventory, as well as the data on the use and application of inorganic fertilisers, which in turn, are consistent with the National Balances on the use of Nitrogen in Spanish Agriculture (BNAE).

For the scenario with additional measures, the policies and measures described in the corresponding chapter of this report were taken into account.

The projected emission estimates for all agricultural activities were made jointly and coherently both for GHGs (CO_2, CH_4 y N_2O) and for emissions of associated atmospheric pollutants (NH_3, COVNM, PM2.5, SOx, NOx y CO) to be included in the Air Pollution Control Programme.

3. Projections of the Waste sector

For the projection of emissions derived from the management and treatment of waste, the historical inventory data were used as starting data (since 1950 for landfills and since 1990 for the rest of activities). These data are consistent with the official national series (Subdirectorate-General for Waste of MITECO and INE) and those published in EUROSTAT.

The evolution forecasts of total waste generation (CRF 5A, B and C1 activities), as well as the distribution of the management and treatment systems at national level for the Baseline Scenario were provided by the competent unit (Subdirectorate-General for Waste of MITECO). For the scenario with additional measures, the policies and measures described in the corresponding chapter of this report were taken into account.

With regard to emissions arising from wastewater treatment CRF 5D activity), the projection was linked to the projection of the national population, considering that the activity has reached maturity in terms of its development (maximum percentages of treated population, volume of treated water, protein consumption, equilibrium in the treatment systems and maximum efficiencies in the capture of the CH4 generated and its use).

The calculation of emissions was carried out in a manner consistent with the methodologies used in the National Emissions Inventory (based on the 2006 IPCC Methodological Guidelines and normally with Tier 2 methodological approaches).

4. Product Use Sector Projections

This sector mainly includes activities related to the use of lubricants and solvents (CRF 2D activity) and the use of fluorinated gases (CRF 2F and G activity).

The projection of the variables of activities linked to the use of lubricants and solvents was linked through elasticities to the GDP and population projection determined in the general macroeconomic context of the National Plan.

For emissions of fluorinated gases in refrigeration and air conditioning activities, foaming agents and firefighting equipment, projections were made according to objectives of Regulation EU No 517/2014 on fluorinated gases which foresees a reduction of 2010 emissions by two-thirds in 2030 and sales of 2014 F-gases by 79 % in the year 2030.

The variety of activities considered within the CRF 2G category (SF6 in electrical and medical equipment, N2O in anaesthesia and aerosols (whipped cream), tobacco consumption and fireworks) was projected by linking the activities directly to GDP.

No policies or measures beyond those currently in place were taken into account for the construction of the scenario with additional measures.

The projected emissions estimate was carried out in a manner consistent with the methodologies used in the National Emissions Inventory (based on the 2006 IPCC Methodological Guidelines and normally with tier 2 methodological approaches).

5. LULUCF sector projections

The projections of absorptions and emissions from the land use, land-use change and forestry (LULUCF) sector were made by applying the same calculation model used in the National Emissions Inventory in its 2018 edition (1990-2016 series and reference year 2016). This calculation system applies the 2006 IPCC methodological guidelines and makes use of data series of available area uses and changes from 1970 to 2016.

The land use change matrices for the period 2017-2040 were built on trends observed in historical data. Only additional areas were included in the reforestation for the construction of the scenario with additional measures according to the measures described in the corresponding chapter of this report.

The forecasts of consumption and use of wood products were based on historical inventory data linked to GDP. For transitions between crops, the incidence of forest fires, the growth of forest biomass or the implementation of agricultural soil conservation practices (activities with notable impact on emission and absorption estimates in the LULUCF sector of the Spanish

Inventory), different future projection approaches based on historical data from the National Inventory and historical trends were applied.

The forest reference level for the period 2021-2025 was set using data from the reference period (2000-2009) of the National Forest Inventory as described in the National Forest Accounts Report and as provided for in Regulation (EU) No 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land-use change and forestry in the 2030 climate and energy framework.

The accounting for LULUCF absorption was also carried out in accordance with Regulation (EU) No 2018/841.

B.2.2. M3E MODEL DESCRIPCION

The M3E model (Modelling of Mitigation Measures in Spain) is a model that enables the joint evaluation of sectoral mitigation measures and which has been used for the evaluation of the contribution of measures from diffuse non-energy sectors to the objectives of this Plan, i.e., agriculture and livestock, waste management, and fluorinated gases.

The input variables are defined for each measure included in the model and for each year analysed, always taking into account that the assigned values refer to the unit defined for the specific measure, such as m^2 of dwelling, t of bio-waste, 1 million passenger-km, etc. These variables are grouped into the following categories:

- definition of the measure
- investment
- operation and maintenance
- time frame
- CO_2 mitigation – energy
- field of application of the measure
- type of measure

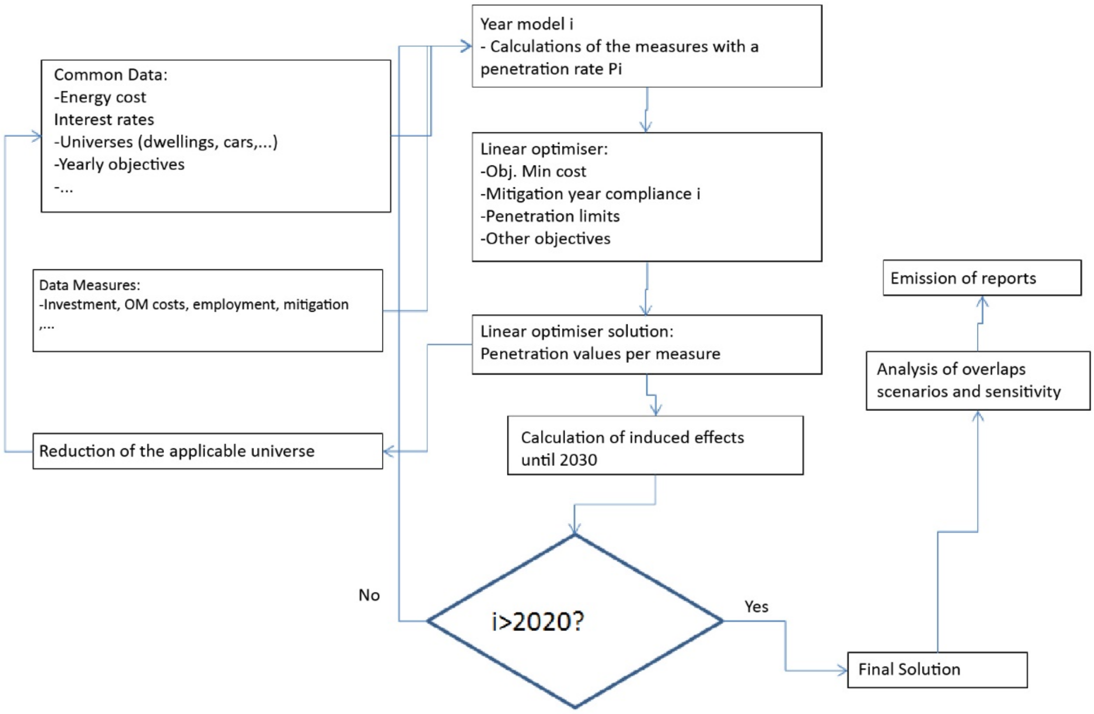
The model identifies mitigation by measure in the years in which it applies to a potential universe. It also deducts from the universe in each year those units (dwellings, vehicles, etc.) on which it has already acted in previous years.

According to the type of the measure, it estimates mitigation with predefined equations (negative exponential in the case of waste, polynomial in the case of sinks, etc.).

M3E, based on input data, applies a linear optimisation problem-solving engine to search for an objective (minimise a cost), complying with a series of restrictions such as meeting the mitigation objective and proposing degrees of application of realistic measures within maximum and minimum values. In our case, the objective chosen to apply the model was to minimise a function composed of the cost of applying the measures, which also includes the use and cost of CO_2.

The model is supported in an Excel format which gives flexibility for the incorporation and modification of data in the future, as well as its management by civil servants to ensure the continuity of revisions.

Figure B.5 Structure of the M3E Model



Source: Basque Centre for Climate Change, 2019.

Based on the input data and the execution of the linear optimiser, for each year, it searches for the cost-effective combination of measures within the possible ranges of application that enable the mitigation objective to be reached. The net present value (NPV) and the marginal abatement cost (MAC) per tonne of CO_2 are used as the cost of each measure.

Taking into account the penetration percentage determined by the linear optimiser, the spreadsheet provides total results for each year and measure of the following variables:

- mitigation in diffuse sectors ($MtCO_2$/year)
- mitigation in ETS sectors ($MtCO_2$/year)
- total mitigation ($MtCO_2$/year)
- investment in the year (€ m)
- annual O&M expenses (€ m/year)
- total cost (€ m)
- energy savings (kWh/year)
- employment per investment (men/year)
- O&M employment (men/year)
- local economic activity in year of installation (€ m)
- local economic activity in successive years (€ m)
- pay back
- tax revenue by investment (€ m)

- annual fiscal balance (€ m)
- possible co-benefits (2 variables to be defined)

With this output information, the graphs and tables illustrating the results obtained are subsequently drawn up.

In addition, the model evaluates aspects such as the possible overlapping of measures that could result in double counting of the mitigation produced. Sensitivity analysis of key parameters is possible.

B.3 IMPACT ANALYSIS MODELS

B.3.1 DENIO MODEL DESCRIPCION

The DENIO model was used in this study for the analysis of the economic impact of the different measures and scenarios of the INECP. DENIO is a dynamic neo-Keynesian econometric model and represents a hybrid between an econometric input-output and a computable general equilibrium (CGE) model. It is characterised by the integration of institutional rigidities and frictions that cause fiscal policies and investments to have a different impact in the short term than in the long term. In the long run, the economy always converges towards full employment equilibrium and in that equilibrium phase the model works in a similar way to a CGE model. Unlike a CGE model, DENIO explicitly describes a path of adjustment towards this equilibrium.

DENIO is a disaggregated model with a detail of 74 sectors, 88 products, 22 000 types of households and 16 categories of consumption. The model equations were estimated econometrically using data from INE, Banco de España and EUROSTAT. The model is calibrated for base year 2014.

DENIO is inspired by the Fully Interregional Dynamic Econometric Long-term Input-Output Model of the European Commission - FIDELIO (Kratena et al., 2013, Kratena et al. 2017). The FIDELIO model was used by the European Commission to analyse the economic impact of the Clean Air Package (Arto et al., 2015). A model with these characteristics was also used in the Basque Country (DERIO: Dynamic Econometric regional Input-Ouput model) 81 to analyse the economic impact of the 2050 Climate Change Strategy of the Basque Country.

The economic growth in DENIO is in the long term driven by the growth of total factor productivity (TFP) to which a path of prices, and therefore, of export competitiveness corresponds. Exports are exogenous and adjust in the Baseline Scenario to the path of GDP growth provided by the MINECO. Imports are endogenous and there is no equilibrium condition on the external balance.

In DENIO there are two mechanisms that determine the Keynesian characteristic of the model in the short term and the long-term CGE characteristic: (i) the heterogeneity of the marginal propensity to consume with respect to disposable income, according to the situation of the financial sector and (ii) the effect on wages/prices when the economy is at or below the equilibrium unemployment rate (NAIRU). The marginal propensity to consume also varies according to income groups. This was derived from estimates of the consumption sensitivity to long-term income (Kratena, et al., 2017).

The household demand sub-model comprises three levels at which the demand made by the 22 000 types of households for a total of 16 expenditure categories is determined. At the first level, the demand for durable goods (dwellings and vehicles) and the total demand for non-durable goods are derived. The second level links energy demand (in monetary and physical units) with the stock of durable goods (houses, vehicles, household appliances), taking into account the energy efficiency of the stock. At the third level, nine categories of demand for non-durable consumer goods are determined in a flexible demand system - Almost Ideal Demand System. Finally, total household expenditure in these 16 consumption categories (at purchase prices) is transformed into a consumption vector of 88 products at basic prices using a product/expenditure bridge matrix and the valuation matrices provided by the INE. The model is estimated using micro-data from the Household Budget Survey and the Living Conditions Survey drawn up by the INE.

The model's Input-Output core is based on 2014 Origin and Destination tables (latest available) prepared by the INE. The production model links the production structures (Leontief technologies) of the 74 sectors and 88 products to a Translog model with four production factors (capital, labour, energy and other intermediate inputs). The demand for the energy factor is divided into 25 types which in turn are linked to the model in physical units (terajoules and tonnes of CO_2). The set of energy categories in the energy substitution model is directly linked to two parts of the model: (i) the physical energy accounts (terajoules) by industry (74 + households) and type of energy (25) from Eurostat and (ii) the energy products and industries from the Origin and Destination tables in monetary units. For this purpose, a series of implicit prices are used, which link energy uses/production in physical units (TJ) and in monetary terms. The high level of detail in the energy model makes it possible to link the DENIO model with bottom-up models in the energy/electricity sector (such as TIMES-SINERGIA).

The labour market is specified through wage curves, where wage increases by industry depend on productivity, the consumer price index and the distance to full employment. The demand for intermediate inputs is modelled in three steps. First, the Translog model estimates the total demand for intermediates in each productive sector. Secondly, this demand is disaggregated by using the productive structures of the Input-Output framework's Table of Origin. Finally, the intermediate demand is divided into domestic and imported products. Capital formation is also endogenous and is derived from the capital demand by sector of the Translog model, by applying the product/sector capital formation matrix. The model is closed by internalising parts of public expenditure and investment to comply with the medium-term stability programme for public finances. This model-locking mechanism is part of the public sector module. This module integrates several components of endogenous income: income taxes (with variable rates depending on the income of each household), wealth, capital, products and production, social security contributions, etc. In expenditure, transfers are endogenous and grow at the rate of GDP. Interest payments on public debt are also endogenous and depend on the path of public debt. Government consumption and investment are endogenous because of the model closure described above.

For the INECP simulations, the DENIO model has been used in combination with the TIMES-SINERGIA bottom-up model. Specifically, data such as the energy and electricity mix, energy intensity and efficiency by sector, prices and investments are taken from this model to analyse the economic impacts on key variables such as employment, GDP, trade balance, income distribution, inflation, etc.

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B.3.2 INTEGRATION OF MICRODATA IN DENIO

DENIO incorporates the microdata of the households that represent the entire Spanish population, which makes it possible to evaluate the microeconomic effects and the distributive impacts and their impact at the social level.

The main database used to integrate the 22 000 households in the model is the 2014 Household Budget Survey (HBS). The HBS is a cross-sectional survey representative of the entire Spanish population that compiles annual information on consumption patterns and socioeconomic characteristics of Spanish households. Thus, through the consumption structure of the HBS, the households collected from said survey in DENIO are included. It is worth mentioning that the HBS provides a population factor for each household surveyed. This population factor allows us to increase the consumption of each household and therefore bring the analysis closer to all households in Spain.

However, as expected, the integration of microdata into such a model is not immediate and it was necessary to include data from other statistical sources, as well as to make some assumptions. One of the main limitations of HBS is its scarce information on household incomes, as well as their origin. Although the Household Budget Survey contains information on monthly household income, this variable has a high non-response rate and, as some studies show, tends to under-represent household income (López-Laborda et al. 2016). Thus, in order to calculate the income of each household, the savings estimates calculated for Spain were applied to the total expenditure of each household. The use of savings estimates by income level was chosen for two reasons. The first is that the Household Budget Survey was used for its calculation. The second is that household savings estimates are pre-set at different income levels (quintiles, to be more specific). In this way, using the savings rates per income quintile in the HBS respects the inequality structure existing in Spain.

Finally, it has also been necessary to estimate the origin of the household incomes introduced in the model. In DENIO each household consumes according to the consumption structures of each one of the consumption nodes and according to their available income. This disposable income depends on different sources of income. In DENIO, to calculate the disposable income of households, the following eight sources of income are taken into account: (1) wages and salaries; (2) gross operating surplus; (3) social contributions; (4) public sector transfers; (5) property income and dividends; (6) interest paid on debt; (7) wealth taxes and personal income tax; and (8) other income. Given that this information is not included in the HBS, the sources of origin of household income were completed using information from the Living Conditions Survey (LCS). The LCS, as well as the HBS, is a cross-sectional survey representative of the entire Spanish population, and its main objective is to provide a reference source on comparative statistics on income distribution and social exclusion in Europe (INE 2018b).

To complete the sources of income in the HBS, the income structure (taking into account the income sources included in DENIO) of the LCS 2014 was calculated by income group, more specifically by income ventile. Once the average structure of the sources of income by ventile of the LCS was calculated, these same structures are applied to the HBS households according to the income ventile to which each household corresponds.

At the end of the previously detailed process, we have the following information for each of the households to be integrated: consumption patterns, total income, origin of said income and characteristics collected in the Household Budget Survey. Thus, there are 22 000 households prepared to be integrated into DENIO. Finally, integration is carried out through the expenditure and income structures of the 22 000 households, but respecting the values of the national accounts incorporated into DENIO.

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B.3.3 SPECIFICATION OF AIDS DEMAND MODEL

For the specification of the node of consumption of non-durable goods, an estimation of a demand model was carried out to calculate the substitution price elasticities, as well as the elasticities of income of the different goods that make up this node. These elasticities are then used to apply the parameters corresponding to the non-durable goods demand function. For the estimation of the demand model for these goods, the widely known 'Almost Ideal Demand System' (AIDS), proposed in 1980 by Deaton and Muellbauer (1980), was used. The main advantage of this methodology is that it allows a first-order approach to a system of unknown demand. In addition, AIDS models satisfy the axioms of consumer theory and do not impose restrictions on the utility function. More specifically, its logarithmic approach (LAIDS) has been followed, which for a group of goods *n* can be defined as:

$$W_i = \alpha_i + \sum_{J=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left({}^{Y_i}/_{\tilde{p}}\right) + t + \sum\nolimits_{d=1}^{7} d_d + e_{it} \qquad [1]$$

where W_i represents the percentage of consumption of good i (over total consumption of goods included), αi is the constant, p_j is the price of good j, $\tilde{p}$ refers to the Stone Price Index, Y is income (so $Y/\tilde{p}$ represents real income), t is a trend variable that captures the effect of time (taking values of 1 for 2006 and 11 for 2016). Finally d_d is a set of 'd' dummy variables or control variables that capture the effect of different characteristics of the households included: years of crisis (i.e., years subsequent to or prior to 2008); Autonomous Community where it resides; professional status of the main breadwinner; number of household members; sex of the main breadwinner; age of the main breadwinner, and how urbanised the household is. Finally e_{it} is the error term. The sum and homogeneity constraints of equation [1] are as follows:

$$\textstyle\sum_{i=1}^{n} \alpha_i = 1 \qquad [2]$$

$$\textstyle\sum_{j=1}^{n} \gamma_{ij} = 0 \qquad [3]$$

$$\textstyle\sum_{i=1}^{n} \beta_i = 0 \qquad [4]$$

The symmetry condition is given as:

$$\gamma_{ij} = \gamma_{ji} \qquad [5]$$

Finally, the sum of W_i must also satisfy the following:

$$\textstyle\sum_{i=1}^{n} W_i = 1 \qquad [6]$$

The AIDS model is carried out to analyse the demand for non-durable goods, including 9 different groups of goods: (1) food and beverages; (2) clothing and footwear; (3) non-durable household goods (furniture, carpets, crockery, etc.); (4) medical expenses; (5) telecommunications; (6) education; (7) hotels and restaurants; (8) financial services; and (9) other non-durable goods. Since the AIDS model is composed of a system of dependent equations, the equation corresponding to group 9 was eliminated in the estimation process to avoid problems with uniqueness. The elasticity matrix of the AIDS model was calculated using the following expressions:

Marshallian Own-Price Elasticity: $\varepsilon_{ii} = \frac{\gamma_{ii}}{w_i} - \beta_i - 1$ [7]

Marshallian Cross-Price Elasticity: [8]

Income elasticity: $\theta_i = \frac{\beta_i}{w_i} + 1$ [9]

The data used in the estimation process were taken from the microdata of the Household Budget Survey (HBS) (INE, 2018). The HBS is a cross-sectional survey representative of all Spanish households that compiles annual information on consumption patterns and socioeconomic characteristics of households. The HBS collects annual information from about 20 000 households. HBS data for the period 2006-2016 were used to estimate AIDS. One of the main limitations of the estimation carried out is the lack of a continuous household survey, since the HBS is a cross-cutting survey for each year; for this reason, the cross-data for each of the years included in the estimation were used, i.e., the data were not transformed into a continuous time series. In estimating equation [1], household expenditure is used as an income proxy because household incomes are underrepresented in expenditure surveys (see for example Wadud et al., 2009 or López-Laborda et al. 2018) and also because expenditure is a variable closer to permanent vital income and suffers fewer variations throughout the life of individuals (Poterba, 1991). Given that the expenditure groups analysed are made up of different goods and products, the national statistics do not have specific prices for the selected groups, and for this reason it was necessary to construct a price index per group based on the consumer price indices (CPI, INE 2018) of each expenditure subgroup. For this purpose, a Stone Index was constructed for each expenditure group based on the price indices by autonomous community in base year 2006 for each subgroup. One of the main advantages of this process is that it allows for the introduction of heterogeneity in the prices of each expenditure group and individual, and thus facilitates the estimation of the AIDS demand model.

The price and income elasticities obtained are shown in the table. The last column of the table represents income elasticities, while the rest represents price elasticities. The main diagonal (darker color) of the matrix shows the own-price elasticities, while the remaining elements are cross-priced. As can be seen, and as one would expect, the own-price elasticities have a negative sign, while income elasticities are positive.

Table B.4 Price elasticities (own and cross) and income elasticities

	Food	Textiles	B_Household	Health	Communication	Education	Catering	Financial_Serv	Other	Income
Food	-1.76	0.83	0.39	0.89	-0.08	-0.09	0.69	0.13	-0.65	0.58
Textiles	2.71	-2.29	-1.27	-1.36	0.27	0.71	-0.45	-0.32	0.72	1.34
B_Household	1.30	-1.73	-0.23	-1.45	0.78	0.17	-1.42	0.23	1.19	1.30
Health	4.83	-2.18	-1.72	-2.14	1.22	0.74	-1.88	0.28	-0.36	1.41
Communication	-1.29	0.45	0.84	1.11	-0.70	-0.87	0.05	0.52	-0.88	0.58
Education	-5.99	4.58	0.83	2.89	-3.94	-1.92	1.84	1.23	-0.63	1.89
Catering	1.31	-0.32	-0.70	-0.78	-0.05	0.14	-1.65	-0.34	0.91	1.39
Financial_Serv	-0.07	-0.36	0.25	0.26	0.47	0.28	-0.58	-0.59	-0.51	0.74
Other	-1.94	0.39	0.46	-0.18	-0.43	-0.11	0.84	-0.29	-0.23	1.37

Source: Basque Centre for Climate Change, 2019.

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B.3.4 DESCRIPTION OF TM5-FASST

The TM5-FASST is a global air quality source-receptor model (AQ-SRM) developed by the Joint Research Centre (JRC) of the European Commission in Ispra, Italy. It enables the analysis of the effects in terms of health or ecosystem damage derived from different scenarios or emission pathways. Through meteorological or chemical-atmospheric information, the model analyses how emissions from a given source affect different receptors (in cells) in terms of concentration, exposure and, consequently, premature deaths. All documentation on this model can be found in Van Dingenen et al., 2018. It has been used to carry out different studies at a global or regional level, among which are Kitous et al., 2017 and Markandya et al., 2018. It has also been used by institutions such as the OECD to project the future possible effects in terms of health (OECD, 2016).

The concentration levels of a given pollutant are calculated using the following linear equation:

$$\mathrm{C_{ij}(x,y) = c_j(y) + A_{ij}(x,y)E_i(x)} \qquad (1)$$

This equation defines the concentration level of a pollutant j in the receiver/cell and derived from the emission of the precursor i emitted at source x (i.e. C_ij (x,y)) as the sum of a spatial constant (c_j) plus the emission of the precursor i at source x, multiplied by a source-receptor coefficient (A_ij (x,y)) reflecting the relationship between source x and the receiver y.

These coefficients, which represent the different relationships between sources and receivers/cells, have previously been calculated by applying a 20 % disruption in emissions over a reference scenario and calculating concentration levels as explained in equation (1). Although the model covers the entire world using 1x1 (100 km) cells, this process was performed for 56 regions (sources). Thus, each of these coefficients, for each receiver, can be defined by the following equation:

$$\mathrm{A_{ij}(x,y) = \Delta C_j(y)/\Delta E_i(x)} \qquad (2)$$

Where $\mathrm{\Delta E_i(x) = 0.2 * e_i(x)}$, is $\mathrm{e_i(x)}$ the emissions in the reference scenario.

It should be borne in mind that in addition to the fact that gases emitted at a certain source x may affect different receptors y, each precursor may also indirectly affect the concentration levels of more than one pollutant j. For example, emissions of NOx (a precursor gas) affect not only the formation of $PM_{2,5}$ particles in the atmosphere, but also ozone (O_3) levels.

Therefore, the level of total concentration of the pollutant j in the receiver (the cell) and, which results from the emission of all its precursors i, in all sources x is defined as:

$$\mathrm{C_j(x,y) = c_j(y) + \sum_x \sum_i A_{ij}(x,y)[E_i(x) - e_i(x)]} \qquad (3)$$

Once the concentration levels of pollutants have been obtained, the model makes it possible to analyse different effects derived from these levels, such as the impacts of pollution on health, possible damage to agricultural systems, or depositions in the Arctic. However, this study focuses on the effects of fine particulate matter ($PM_{2,5}$) and ozone concentration levels on human health.

These effects are calculated as premature deaths from exposure to these pollutants ($PM_{2,5}$ and O_3), taking into account the various causes defined in Forouzanfar et al., 2016a, including cardiovascular diseases, respiratory diseases, embolisms or lung cancer. The parameters and calculation of premature deaths from disease are detailed in Burnett et al., 2014.

Once the premature deaths have been calculated, with the aim of carrying out a cost-benefit analysis, the statistical value of life is applied in order to monetise these effects and incorporate them into the analysis. Despite the existence of different instruments or metrics to monetise the damage to health arising from exposure to local pollutants ($PM_{2,5}$ and O_3), in this study the statistical value of life is used, leaving aside potential costs such as, for example, reductions in productivity.

The Statistical Life Value (SLV) is the monetary value of a relative reduction in the probability of mortality risk. Due to its nature, it is usually estimated by indirect methods, such as surveys or hedonic regressions that relate wages to mortality risk. Since not all regions have carried out this type of study directly, various methods were developed to extend the results obtained to these regions.

One of these main methods is the Unit Value Transfer Approach, which, taking the calculated (and widely accepted) value for the OECD regions ($1.8 - $4.5 million) as a reference, adjusts the SLV to each region based on parameters such as GDP or the GDP growth rate. Specifically, the SLV of a country c in year t will be defined as:

$$\mathrm{VSL}_{\mathrm{c,t}} = \mathrm{VSL}_{\mathrm{OCDE,2005}} * \left(\frac{\mathrm{Y}_{\mathrm{c,2005}}}{\mathrm{Y}_{\mathrm{OCDE,2005}}}\right)^{\mathrm{b}} * (1 + \%\Delta\mathrm{Y})^{\mathrm{b}}$$

$\mathrm{VSL}_{\mathrm{c,t}}$ is the SLV of country c in year t; $\mathrm{VSL}_{\mathrm{OCDE,2005}}$ is the value for the OECD in the base year (2005); Y is the GDP per capita; %ΔY the rate of income growth and b is the income elasticity of the SLV that for this study, which we assume takes a value of 0.8.

Once the SLV has been obtained for each region and period, we estimate the morbidity costs. The literature (Narain and Sall, 2016) includes direct costs in morbidity, related to the health system (treatments, hospitalisations, ambulances, etc.) indirect costs as incapacities or opportunity costs. However, although some studies have attempted to normalise the estimation by applying generalised patterns (Searl et al., 2016a), there is still no widely accepted methodology for calculating morbidity. For this study, as in Markandya et al., 2018, OECD guidelines are used which estimate that these costs account for around 10 % of total mortality costs.

Since there is a large degree of uncertainty, the estimates will be presented as a range of values consistent with this methodology, in addition to applying the SLV data currently used by WHO. In the case of cumulative values for the analysis period (e.g., from 2020 to 2030), the net present value is calculated at a discount rate of 3 %. There is broad debate regarding the possible ethical or moral problems of this methodology, given that the regional calculation is based on GDP.

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ANNEX C. MAIN ELEMENTS OF THE FIGHT AGAINST CLIMATE CHANGE IN SPAIN

Name	Sector/s	Objective and/or activity concerned	GHG	I	S	Year I.
MAIN ELEMENTS OF THE FIGHT AGAINST CLIMATE CHANGE IN SPAIN						
INTERSECTORAL POLICIES AND MEASURES						
Operational programmes of the Autonomous Communities	Intersectoral	Regional development and emission reductions, especially under Thematic Objective 4 'Promoting the transition to a low-carbon economy in all sectors'.	CO_2; CH_4; N_2O; HFC	EC	I	2014
Clima Projects	non-ETS	Reduce emissions in diffuse sectors and encourage the development of a low-carbon economic activity.	GHG	EC	I	2012
Carbon footprint recording, offsetting and CO_2 absorption projects	Intersectoral	Promoting the calculation of carbon footprints by Spanish organisations	GHG	I	I	2014
Operational programme for sustainable growth 2014-2020	Intersectoral	Sustainable growth within the ERDF framework. Low-carbon economy, urban development and sustainable growth measures are highlighted	CO_2	EC	I	2015
Implementation of the European Emissions Trading System	ETS	to achieve the reduction of GHG emissions from the energy and industry sectors, through the allocation ceiling of GHG emissions by sector. Objective: Achieve a 21 % reduction in EU ETS emissions by 2020 compared to 2005 levels.	CO_2; N_2O; PFC	EC	I, M	2005
Use of the Kyoto Protocol Flexibility Mechanisms	Intersectoral	Obtaining emission reduction units to facilitate compliance with the Kyoto Protocol, for possible use in both ETS and non-ETS. No provision is currently made for the use of these credits to meet our commitments.	CO_2	M AV	A	2013

Name	Sector/s	Objective and/or activity concerned	GHG	I	S	Year I.
European Union CCS Directive	Intersectoral	Regulations for the geological storage of CO_2 under safe conditions for the environment, in order to contribute to the fight against climate change.	CO_2	N	A	2009
Financing of demonstration projects. NER 300 programme	Intersectoral	Promoting the construction of CO_2 capture and geological storage projects and innovative renewable energy technologies within the EU. Up to 38 projects.	CO_2 N_2O PFCs	RDI	D	2013
SECTORAL POLICIES AND MEASURES						
Energy sector						
Energy Saving and Diversification Investment Fund (FIDAE)	Other Energy	which aims to finance sustainable urban development projects that improve energy efficiency and/or use renewable energy	CO_2	EC	E	2011
Savings and Efficiency Action Plan 2014-2020	Other Energy	achieve final energy savings for the period 2014 - 2020	CO_2	P	I	2014
Electricity and Gas Sectors Planning 2014-2020	Energy	Meeting the 2020 targets for energy efficiency, renewable energy and the environment	CO_2	P	I	2014
Renewable Energy Plan (REP) 2011-2020	Other Energy	encouraging the use of renewable energy sources	CO_2	P	I	2011
Industrial Sector						
Voluntary agreement SF6 - electricity sector	Industrial	Reduction of emissions of fluorinated gases	SF_6	AV	I	2015
Royal Decree 115/2017 on fluorinated gases	Industrial	Reduction of emissions of fluorinated gases	PFC; SF_6; HFC	N	I	2017
National tax on fluorinated greenhouse gases	Industrial	Replace fluorinated gases with other substances; reduction of emissions of fluorinated gases	PFC; SF_6; HFC	F	I	2014
Integrated Pollution Prevention and Control	Industrial	Integration of environmental authorisations for industrial activities	GHG	N	I	2003
Transport Sector						

Name	Sector/s	Objective and/or activity concerned	GHG	I	S	Year I.
ADIF 2014-2020 Energy Efficiency and Savings Master Plan - High Speed	Transport	Energy saving measures and improvement of energy efficiency at high speed	CO_2	N, P,	I	2014
ADIF 2014-2020 Energy Efficiency and Savings Master Plan	Transport	Energy saving measures and improvement of energy efficiency	CO_2	N, P,	I	2014
Framework Agreement for the design, supply and/or installation of energy-efficient lighting systems	Transport - Energy	Improvements in the efficiency of airport lighting systems.	CO_2	AV	I	2015
Carbon footprint accreditation at airports	Transport	Obtaining and renewing carbon accreditation at various airports.	CO_2	AV	I	2011
Supply of electricity at 400 Hz to aircraft at airports	Transport - Energy	Promote the use of electricity for parked aircraft	CO_2	P	I	2016
Progressive incorporation of renewable energies in airports	Transport - Energy	Use alternative energy sources and diversify energy production at airports.	CO_2	Other	I	2000
Optimisation of aircraft taxiing movements	Transport	Minimise aircraft time and travel at the airport.	CO_2	AV	I	2014
Renewal of fleets of heavy goods and passenger vehicles and agricultural tractors	Transport	Finance the replacement of heavy duty vehicles of companies (with less than 3 000 employees)	CO_2	EC	I	2016
Tendering of concessions for the regular transport of passengers by road	Transport	Establish energy efficiency and pollutant requirements in concession specifications	CO_2	N	I	2014

Name	Sector/s	Objective and/or activity concerned	GHG	I	S	Year I.
Incorporation of criteria encouraging the use of less polluting groundhandling equipment	Transport	Encouraging the use of less polluting equipment	CO_2	Other	I	2015
Aid for the implementation of vehicle fleet management systems	Transport	Implementation of efficient vehicle fleet management systems	CO_2	EC	I	2015
Aid for the financing of urban mobility plans and business mobility plans	Transport	Development of urban mobility plans (modal shift)	CO_2	EC	I	2014
Efficient Vehicle Incentive Programme PIVE PLANS (PIVE I, II, III, IV, V, VI, VII and VIII)	Transport	Renewal of the fleet of light vehicles for more efficient ones	CO_2	EC	E	2012
Efficient driving courses in road transport	Transport	Efficient driving in road transport	CO_2	ED	I	2015
Integrated Strategy for the Promotion of Electric Vehicles in Spain and MOVELE and MOVEA Plans (from 2016)	Transport	Encourage the penetration of electric vehicles, aimed at promoting alternative technologies.	CO_2	EC	I	2010
Plan to Promote the Environment - PIMA Transport [PIMA Transporte]	Transport	Renewal of the road transport fleet	CO_2	EC	E	2014
Plan to Promote the Environment - PIMA Air Plans [PIMA Aire] (I, II, III and IV)	Transport	Renewal of the commercial vehicle fleet	CO_2	EC	E	2013
Royal Decree 1085/2015 of 4 December 2015 on the promotion of Biofuels	Transport	Establish the path for the introduction of biofuels in transport by 2020	CO_2	N	I	2017
Management and service delivery programme	Transport	Efficiency and rationalisation in the use of resources	CO_2	P	I	2012

Name	Sector/s	Objective and/or activity concerned	GHG	I	S	Year I.
Investment action programme	Transport	Infrastructure planning with an intermodal approach, enhancing the most efficient mode in each corridor	CO_2	P	I	2012
Regulation, control and monitoring programme	Transport	Enable the development and implementation of the policies established in each of the modes of transport	CO_2	N	I	2012
Spanish Logistics Strategy	Transport	Promote the Spanish logistics sector, improve the efficiency and sustainability of the transport system and develop an intermodal network	CO_2	N, P,	I	2013
Promotion of urban mobility plans:	Transport	Local authorities to approve mobility plans	CO_2	EC	I	2014
Transport voucher	Transport	Promotion of collective employees transport	CO_2	F	I	2010
Registration tax: Law 38/1992 of 28 December 1992 on excise duty.	Transport	Tax levied according to the level of CO_2 emissions	CO_2	F	I	2008
National Action Framework for Alternative Energy in Transport	Transport	Promotion of alternative fuels in transport by 2020	CO_2	N	I	2017
Cataloguing of the vehicle fleet according to the level of emissions	Transport	Identify the category of vehicles so that town councils can develop environmental policies.	CO_2	N	I	2015
Ecodriving: Order INT/2229/2013, Regulating Access to Registration Permits	Transport	Include efficient driving in the programme to get a driver's license.	CO_2	ED	I	2014
Amendment of the General Traffic Regulations (in process)	Transport	Amend the general speed limits set for vehicles on different types of roads	CO_2	N	P	2017
Motorways of the Sea	Transport	Modal shift in freight from road to ship	CO_2	P	I	2010
Efficiency measures in port management	Transport	Efficient use of the general public lighting service in ports	CO_2	AV	I	2016

Name	Sector/s	Objective and/or activity concerned	GHG	I	S	Year I.
Port Accessibility Investment Plan	Transport	Promote port connectivity and maritime-rail intermodality	CO_2	P	I	2017
Supply of liquefied natural gas (LNG) in ports	Transport	Promotion of the use of LNG in maritime transport,	CO_2	N, P, R&I EC	I	2016
Electricity supply to ships mooring in ports	Transport - Energy	Boost the use of electricity for ships at berth in ports	CO_2	EC	I	2016
RENFE Energy Sustainability Plan 2011-2020	Transport	Management tool to improve energy efficiency and productivity	CO_2	N, P, I,	I	2011
Energy Efficiency Plan 2015-2025 RENFE Travellers	Transport	Reduce energy consumption and costs	CO_2	N, P,	I	2015
Residential, Commercial and Institutional (RCI) Sectors						
Plan to Promote the Environment for the promotion of energy upgrade of hotel facilities - PIMA Sol	RCI	Stimulate the energy upgrade of hotel facilities	CO_2	EC	E	2013
Plans for the Renovation of Tourist Facilities	RCI	Renovation and improvement of tourist establishments under sustainability and energy efficiency criteria	CO_2	EC	I	2009
State Financial Fund for the Modernisation of Tourism Infrastructure	RCI	Financially support plans for the renewal, modernisation and comprehensive conversion of mature tourist destinations	CO_2	EC	I	2005
Upgrading of the General State Administration (AGE) buildings	RCI	Energy upgrade of the building stock	CO_2	P	I	2015
Regulation of Thermal Installations of Buildings (RITE)	RCI	Increase the minimum energy efficiency requirements for heating and air-conditioning systems in buildings	CO_2	N	I	2013

Name	Sector/s	Objective and/or activity concerned	GHG	I	S	Year I.
Grant programme for the energy upgrade of existing buildings (PAREER-CRECE Programme)	RCI	Improvement of the thermal envelope, thermal and lighting installations, use of renewable energies	CO_2	EC	I	2013
Technical Building Code (CTE)	RCI	Greater demands on energy efficiency and the incorporation of renewable energies	CO_2	N	I	2013
Law 8/2013 on Urban Renovation, Regeneration and Renewal	RCI	Facilitate the approval of projects for the energy upgrade of buildings and urban regeneration.	CO_2	N	I	2013
State Housing and Upgrade Plan and State Plan for the Promotion of Urban Renting, Building Upgrades, Regeneration and Renewal (2013-2016)	RCI Energy	Improvement of the thermal envelope, air-conditioning systems, installation of renewable energies and energy efficiency	CO_2	P	I	2013
Energy Certification of New and Existing Buildings:	RCI Energy	Royal Decree 235/2013 of 5 April 2013 approves the basic procedure for the certification of the energy efficiency of buildings and dwellings, and their improvement.	CO_2	N	I	2013
Agricultural sector						
Maritime and fisheries operational programme	Agricultural	Several measures contribute to Thematic Objective 4 ‘Promoting the transition to a low-carbon economy in all sectors’.	CO_2	EC	I	2014
Plan to Promote the Environment - PIMA Land [PIMA Tierra] (renewal of tractor fleet)	Agricultural	Renewal of the fleet of tractors for more efficient ones with less emissions	CO_2	EC	E	2014
Ecodriving of tractors	Agricultural	Reduction of emissions due to good driving practices	CO_2	ED	I	2014
National programme for promoting crop rotation on unirrigated land	Agricultural	Reduce emissions through better use of resources and best practices	N_2O; CO_2	EC	E	2010

Name	Sector/s	Objective and/or activity concerned	GHG	I	S	Year I.
Strategy to support organic production	Agricultural	Promotion of measures which can contribute to the development of organic production.	N_2O; CO_2	P	I	2014
Greening or Green payment	Agricultural	Payment for climate- and environment-friendly agricultural practices (crop management, enhancing biodiversity, carbon sequestration).	CO_2; CH_4; N_2O	EC	I	2015
Plan to Reduce the Use of Nitrogen Fertilisers	Agricultural	Reduction in the use of nitrogen fertilisers and, therefore, a reduction in emissions, either during their manufacture or their application in the field	N_2O	ED	I	2007
National Programme for Rural Development (PNDR) 2014-2020	Agricultural Forestry	Prevention and restoration after major fires, conservation of forest genetic resources, conservation of forest carbon	CO_2; CH_4; N_2O	P	I	2015
Rural Development Programmes by Autonomous Community 2014-2020	Agricultural Forestry	Reduction of emissions by different measures: management of crops, pastures, soils and livestock, reduction of fertilisation, conservation of forest carbon, forest management and prevention of deforestation.	CO_2; N_2O; CH_4	P	I	2014
Forestry Sector						
Four per thousand initiative for soil organic carbon augmentation and food security	Agricultural Forestry	Increase the organic carbon content of soils	CO_2	P	P	2017
Restoration of forest cover and extension of wooded area	Forestry	Afforestation	CO_2	N, P,	I	1990
Sustainable Forest Management	Forestry	Sustainable Forest Management	CO_2; CH_4; N_2O	N, P,	I	1990
Waste Sector						
Plan to Promote the Environment - PIMA Waste (PIMA Residuos)	Waste	Promote the collection and treatment of organic matter, the capture of biogas and its use.	CH_4; N_2O	EC	E	2015

Name	Sector/s	Objective and/or activity concerned	GHG	I	S	Year I.
'More food, less waste' strategy	Waste	Reduction of food waste	CH_4; N_2O	I	I	2013
State Waste Prevention Plan 2014-2020	Waste	Reduce waste generation	CH_4; N_2O	P	I	2014
State Waste Framework Plan 2016-2022	Waste	Implementing the Waste Management Hierarchy	CH_4; N_2O	P	A	2016

I = AV, voluntary agreement; EC, economic; ED, education; F, fiscal; I, information system; RDI, research, development and innovation; N, normative/regulatory; M, market; P, plans and programmes
S = A, adopted; I, implemented; P, planned; E, expired (if still in effect)
S.D. indicates no data, non-quantifiable N.C., and I.O. integrated at another level.

ANNEX D. STUDIES OF BASELINE AND TARGET SCENARIOS FOR THE INTEGRATED NATIONAL ENERGY AND CLIMATE PLAN. 2025 AND 2030 TIME FRAMES - RED ELÉCTRICA DE ESPAÑA

The purpose of this document is to present the results of the generation dispatch of the ‘Baseline’ and ‘Target’ scenarios defined by MITECO within the Integrated National Energy and Climate Plan for the 2025 and 2030 time frames.

It also includes a brief description of the methodology and model used, as well as the adaptation of assumptions of the national scenarios defined by MITECO for use in the European studies model.

Methodology

The analysis of the scenarios defined for the Spanish electricity system consists of the simulation, under the assumptions that will be described later, of the generation dispatch in Europe, in a similar way to the studies that are carried out by ENTSO-E for the drafting of the European Ten Years Network Development Plan (TYNDP).

The studies use a simplified model of the European system in which each modelled electricity system (price zone) is represented as a single node interconnected with its neighbouring systems with the commercial exchange capacity value deemed available to the market (NTC - Net Transfer Capacity).

Within each price zone, the generation dispatch calculation considers a single node, i.e., no losses or possible generation limitations due to elements of the internal network of each system are taken into account. The model uses a constant value of commercial exchange capacity between the modelled systems at all times on the simulation time frame and therefore does not take into account variations that would correspond to different operating situations or reductions in their value due to unavailability of the transmission network or other circumstances.

The simulations use as a base assumption a perfectly competitive market in electricity generation, and therefore do not include the possible strategies of the generators to maximise their profits: the supply of each generator is equal to its estimated variable cost and the generation dispatch is obtained by minimising the variable cost of generation in the European system as a whole, under the condition of supplying the demand for electricity in all the systems in the time frame analysed.

Variable generation cost values are based on forecasts of fuel prices, estimated operating and maintenance costs for each technology, and CO_2 emission costs. Fixed generation costs, costs of dismantling generator sets currently in service and not considered in the scenario to be evaluated, possible costs of extending the useful life of generator sets or other factors (tariffs, taxes, etc.) that may influence the generation's supply strategy are not considered.

The model considers zero variable cost for renewable generation. Cogeneration, as well as renewable generation, is considered with zero variable cost, which gives them dispatch priority over the rest of thermal generation technologies.

For the purposes of generation dispatch calculation, each thermal generation unit is modelled with its operating parameters, availability and accidental failure rates. Hydroelectric generation is modelled consistently with historical production series and wind; photovoltaic and thermosolar generation, using primary resource climatic historical series.

For each scenario, a complete generation dispatch simulation of the European system modelled during each hour of the year is carried out, respecting all group restrictions (start-up restrictions, stoppages, loading and unloading times, etc.) while minimising the total variable cost. In the simulations presented, a restriction of a minimum value of 5 500 MW has been implemented for all coupled thermal generation in the Iberian Peninsula.

As a result, the values of energy generated by each thermal unit and modelled generation technology, the values of marginal cost and exchange balance resulting from the total variable cost minimisation process in the modelled set, respecting the exchange capacity values, are obtained with a detailed schedule. Using these results, the total value of renewable generation and the fraction it represents of electricity generation and demand in the Spanish mainland system are calculated.

It is very important to note that cost results should not be interpreted as prices and that the results obtained from the exchange of energy between interconnected systems are only the result of the marginal cost difference between these systems with the limitation of the commercial exchange capacity value considered in the scenario.

Adaptation of the scenarios defined by MITECO to the European model.

Firstly, the European scenario used as the basis for the study includes the assumptions provided by MITECO, which constitute the basis for calculating the variable unit cost of electricity generation of each thermal generation technology. These new variable costs are applicable to the entire generation fleet considered in the European model.

The inclusion in the European model of each scenario proposed by MITECO for the Spanish electricity system requires the adaptation of assumptions relating to the installed generation capacity of each technology and its dispatch characteristics in order to determine the values corresponding to the scope of the Spanish mainland electricity system, as well as the conversion of power values to net values. The assumptions obtained form the scenario which is henceforth called the adapted peninsular scenario.

Finally, in the European scenario used as a basis, the generation system in the Spanish area is replaced by the adapted peninsular scenario obtained in the process above. At this point it should be noted that the installed generation assumptions in the other systems maintain the original generation system of the European scenario, so that the results obtained only include the assumptions of the Integrated National Energy and Climate Plan in Spain. The proposal-defining process of energy and climate plans by the EU member states, as in Spain, is in the drafting stage and therefore, the electricity generation dispatch simulations at European level of the set of scenarios included in the energy and climate change plans of the Member States could offer different results, depending on the degree of overlap of these with the scenarios currently available within the scope of the TYNDP.

Two possible scenario paths were defined by MITECO in order to carry out the simulation of the generation dispatch:

- Baseline scenario
- Target Scenario

For each of these paths, the scenarios corresponding to 2025 and 2030 time frames will be simulated.

The European scenarios used as the basis for the studies described in this report are ENTSO-E's Best Estimate 2025 scenario (BE2025) for the scenarios on the 2025 horizon and the Distributed Generation scenario (DG2030) for the scenarios on the 2030 horizon.

Assumptions of the scenarios defined by MITECO and values of the corresponding adapted scenario.

This section presents the assumptions of the scenarios defined by MITECO and, where appropriate, the corresponding values of the adapted peninsular scenario. The variable generation cost assumptions are used for all the generation installed in the European model.

Variable generation costs

For the determination of the variable cost values of the thermal generation technologies, the following fuel cost and CO_2 emission cost values are used for the 2025 and 2030 horizons set in the MITECO scenarios. For the rest of the fuels, the values of the scenario used as the base from TYNDP2018 are maintained.

Table D.1 Fuel prices and CO_2 emissions considered for the 2025 and 2030 horizon

		Scenarios MITECO		Scenarios **ADAPTED**	
		2025	2030	2025	2030
€/net GJ	Nuclear			**0.47**	**0.47**
	Lignite			**1.1**	**1.1**
	Hard coal	3.2	3.8	**3.2**	**3.8**
	Gas /	9.6	10.5	**9.6**	**10.5**
	Light oil			**18.7**	**21.8**
	Heavy oil			**15.3**	**17.9**
	Oil shale			**2.3**	**2.3**
€/tonne	CO2 price	23.3	34.7	**23.3**	**34.7**

0 más adelante The emission factors of each technology used in the European-wide model are included according to the criterion established in TYNDP 2018.

For the generation dispatch simulations carried out in this study, the emission factor considered for cogeneration is **0.575 t/MWh**, a value calculated on the basis of the information provided by MITECO.

Table D.2 Emission factors by technology. TYNDP 2018

Fuel	Type	*Standard efficiency in NCV terms*	CO_2 emission factor	CO_2 emission factor
		%	kg/Net GJ	t/MWh
Nuclear	-	*33%*	0	0,000
Hard Coal	Old 1	*35%*	94	0,970
Hard Coal	Old 2	*40%*	94	0,848
Hard Coal	New	*46%*	94	0,738
Hard Coal	CCS	*38%*	9,4	0,089
Lignite	Old 1	*35%*	101	1,042
Lignite	Old 2	*40%*	101	0,912
Lignite	New	*46%*	101	0,793
Lignite	CCS	*38%*	10,1	0,096
Gas	Conventional old 1	*36%*	57	0,572
Gas	Conventional old 2	*41%*	57	0,502
Gas	CCGT old 1	*40%*	57	0,514
Gas	CCGT old 2	*48%*	57	0,429
Gas	CCGT new	*58%*	57	0,355
Gas	CCGT CCS	*51%*	5,7	0,040
Gas	OCGT old	*35%*	57	0,588
Gas	OCGT new	*42%*	57	0,490
Light oil	-	*35%*	78	0,805
Heavy oil	Old 1	*35%*	78	0,805
Heavy oil	Old 2	*40%*	78	0,704
Oil shale	Old	*29%*	100	1,245
Oil shale	New	*39%*	100	0,926

As a result of the previous assumptions of fuel prices and CO_2 emissions, the variable generation costs of the generation technologies considered in the European scenario are obtained, which are presented in 0 and 0. In these figures, the technologies installed in the Spanish peninsular system are those represented in orange.

Figure D.1 Cost of generation of H2025 scenarios by technology. Price of CO_2 €23.3/t

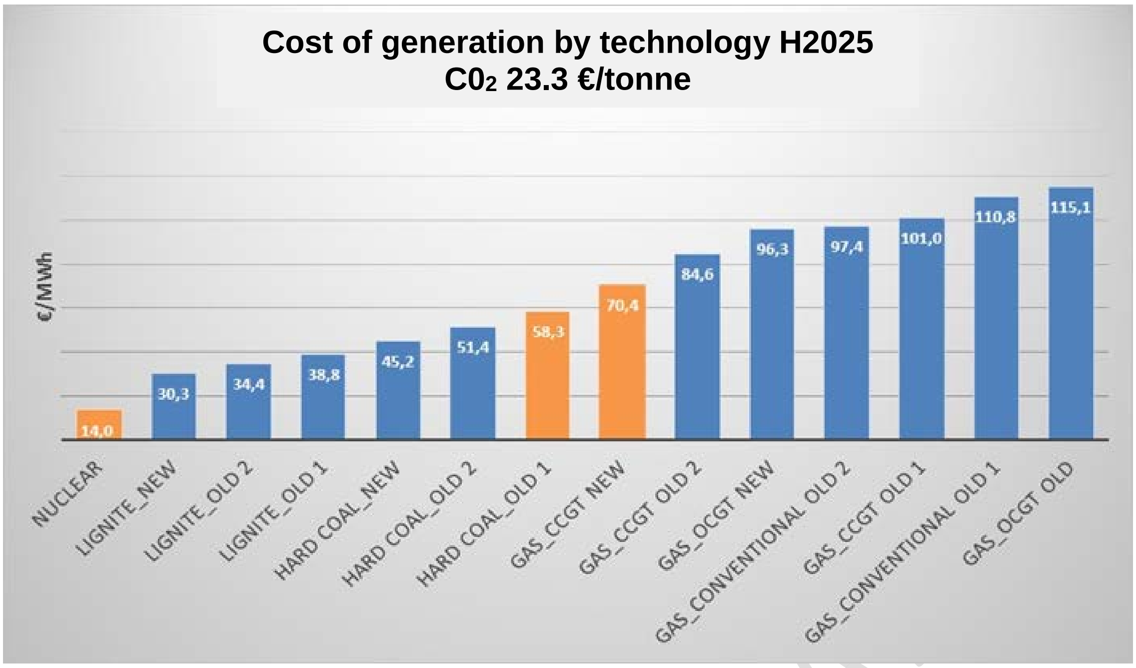
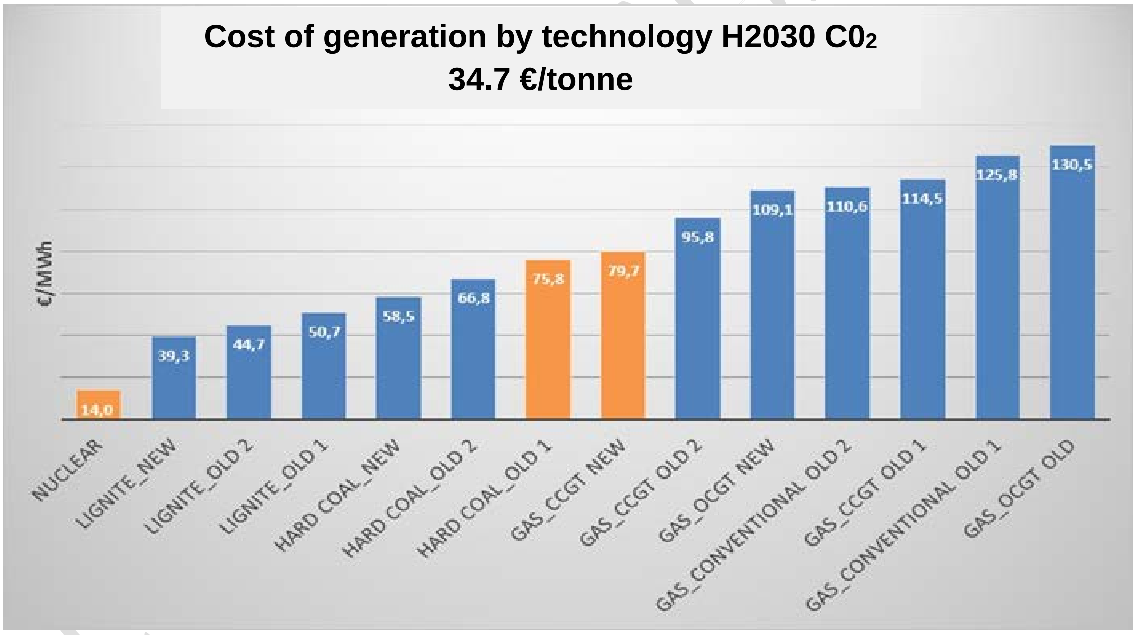


Figure D.2 Cost of generation of H2030 scenarios by technology. Price of CO_2 €34.7/t



Hours of renewable generation operation

The operating hours indicated by MITECO and considered in the simulations for the Spanish peninsular system are listed in 0.

Table D.3 Annual operating hours per technology

Technology	Hours operation yearly **MITECO**
Wind	2 100 / 2 500
Existing solar thermal	2 250
Future solar thermal	3 594
Photovoltaic	1 800
Cogeneration and others	4 210
Other RES	5 000

Electricity demand

In order to establish the forecast electricity demand values, the national values provided by MITECO were adapted to values for the Spanish peninsular system in the different scenarios and time frames analysed. In the rest of the electricity systems, the values of the ENTSO-E scenario for the 2025 horizon (Best Estimate 2025) and the Distributed Generation (DG) scenario for the 2030 horizon are used.

The values considered in the model - adapted peninsular scenario - for the baseline scenario path are shown in 0. The values corresponding to the target scenario path are shown in 0.

Table D.4 Demand values MITECO H2025 and H2030 baseline scenario.

Electricity demand	**Scenario Baseline MITECO (national)**		**Scenario Baseline Peninsular ADAPTED**	
	2025	**2030**	**2025**	**2030**
Demand at power station busbars National (TWh)	**274.1**	**279.2**	**274.1**	**279.2**
Demand at power station busbars Peninsular (TWh)	**-**		**258.3**	**263.0**
Peninsular Demand peak (MW)	**-**		**46 200**	**48 652**

Table D.5 Values of electricity demand MITECO H2025 and H2030 target scenario

Demand	Target Scenario MITECO (national)		Target Scenario Peninsular **ADAPTED**	
	2025	2030	2025	2030
Demand at power station busbars National (TWh)	272.4	284.0	**272.4**	**284.0**
Demand at power station busbars Peninsular (TWh)			**256.3**	**267.5**
Peninsular Demand peak (MW)			**46 200**	**48 652**

Installed generation fleet

The most relevant aspects regarding the generation system considered by MITECO in the baseline scenarios are the maintenance of the nuclear fleet currently in service and the reduction of the generation system using coal with in comparison with the current one in 2025, remaining unchanged in the period 2025-2030. Moderate growth in wind and solar photovoltaic generation is considered, while the current thermosolar generation system is maintained in both horizons. Cogeneration reduces its capacity gradually from the value currently in service to the 2030 horizon.

Table D.6 Installed capacity of MITECO H2025 and H2030 Baseline scenario

Technology. Data in MW	MITECO Scenario (national)	Baseline	Baseline scenario Peninsular **ADAPTED**	
	2025	2030	2025	2030
Nuclear	7 400	7 400	**7 117**	**7 117**
Imported coal	4 480	4 480	**4 236**	**4 236**
National coal	50	50	**0**	**0**
Combined cycle	27 150	27 150	**24 560**	**24 560**
hydroelectric power	15 750	15 750	**20 140**	**20 140**
Pumping	4 390	4 390		
Wind	32 970	37 970	**31 666**	**36 290**
Solar photovoltaic	13 400	18 380	**12 784**	**17 634**
Solar thermoelectric	2 300	2 300	**2 300**	**2 300**
Biogas	230	230		
Biomass	880	880		
MSW	230	230		
Marine energy	0	0		
geothermal energy	0	0		
Other RES	1 340	1 340	**1 340**	**1 340**
Coal cogeneration	0	0		
Gas cogeneration	3 230	1 890		
Petroleum products cogeneration	400	230		
Renewables cogeneration	370	270		
Waste cogeneration	20	10		
Cogeneration and other	4 020	2 400	**4 020**	**2 400**
Fuel/Gas (TNP)	2 790	2 790	**0**	**0**
Total peninsular	**116 040**	**124 400**	**108 163**	**116 017**
Storage	0	0	**0**	**0**

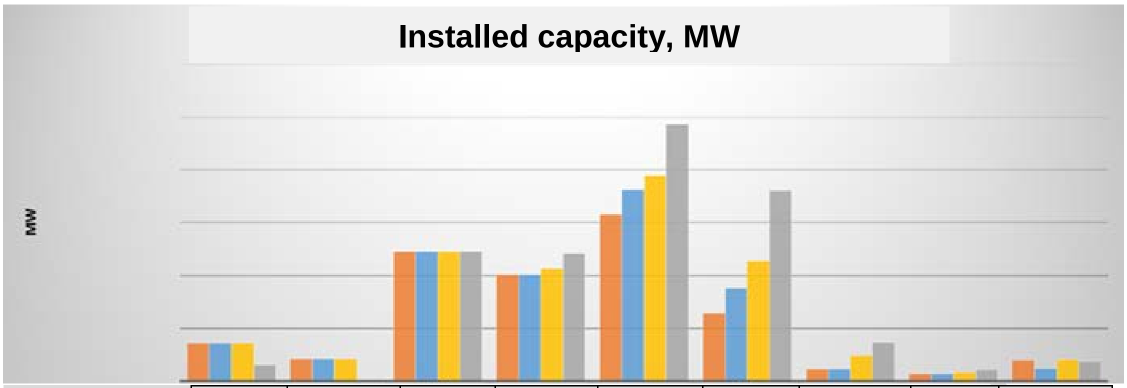
In relation to the generation fleet considered by the MITECO in the target scenarios, it is worth mentioning the gradual reduction of the nuclear generation system, considering that three nuclear generator sets will be available in 2030 out of the seven currently available; and the gradual closure of the coal generation system until its disappearance in the 2030 horizon. It is considered that there will be a strong growth of the generation system using renewable energies, mainly in wind and solar photovoltaic generation, compared to the system currently in service. A new solar thermal generation facility is predicted during the period under consideration. The cogeneration is gradually reduced compared to the current value.

Table D.7 Installed capacity of MITECO H2025 and H2030 Target scenario

Technology. Data in MW	Target scenario MITECO (national)		Target scenario Peninsular **ADAPTED**	
	2025	2030	2025	2030
Nuclear	7 400	3 180	**7 117**	**3 050**
Imported coal	4 480	0	**4 236**	**0**
National coal	50	0	**0**	**0**
Combined cycle	27 150	27 150	**24 560**	**24 560**
Hydroelectric power	16 000	16 250	**21 260**	**24 140**
Pumping	5 260	7 890		
Wind	40 260	50 260	**38 956**	**48 580**
Solar photovoltaic	23 400	36 880	**22 784**	**36 134**
Solar thermoelectric	4 800	7 300	**4 800**	**7 300**
Biogas	230	230		
Biomass	1 080	1 680		
MSW	230	230		
Marine energy	30	50		
geothermal energy	20	30		
Other RES	1 590	2 220	**1 590**	**2 220**
Coal cogeneration	0	0		
Gas cogeneration	3 230	3 000		
Petroleum products cogeneration	400	230		
Renewables cogeneration	490	490		
Waste cogeneration	30	30		
Cogeneration and other	4 150	3 750	**4 150**	**3 750**
Fuel/Gas (TNP)	2 440	2 090	**0**	**0**
Total peninsular	**136 980**	**156 970**	**129 453**	**149 734**
Storage	500	2 5000	**500**	**2 500**

In 0 the net capacity values corresponding to each generation technology in the Spanish peninsular electricity system are included in the scenarios analysed.

Figure 3 Installed capacity in the Spanish Peninsular System MITECO H2025 and H2030 baseline and target scenarios



	Nuclear	Coal	Cycle Combined	Hydroelectric power	Wind	Solar Photovoltaic	Solar thermal	Other RES	Cogen and others
Baseline Scenario 2025	7 117	4236	24 560	20 140	31 666	12 784	2 300	1 340	4 020
Baseline Scenario 2030	7 117	4 236	24 560	20 140	36 290	17 634	2 300	1 340	2 400
Target Scenario 2025	7 117	4 236	24 560	21 260	33 956	22 734	4 800	1 590	4 150
Target Scenario 2030	3 050	0	24 560	24 140	43 580	36 134	7 300	2 220	3 750

Ability to exchange with neighbouring electricity systems

The exchange capacity values with France and Portugal are those given in the TYNDP2018 in the 2025 and 2030 horizons.

Table D. 8 Spain-France, Spain-Portugal and Spain-Morocco interconnection values

NTC (MW)	Baseline and Target Scenarios MITECO	
	2025	2030
ES-->FR	5 000	8 000
FR-->ES	5 000	8 000
ES-->PT	4 200	4 200
PT-->ES	3 500	3 500

The exchange between Spain and Morocco is modelled with an exchange profile having an annual balance of 0 GWh.

RESULTS OF 2025 HORIZON SCENARIOS

The complete results of the simulations of the 2025 baseline and target scenarios are presented in 0 and 0 respectively. A comparison of the results obtained for the baseline and target scenarios by 2025 is provided in 0 and 0.

Table D.9 Comparative results of H2025 baseline and target scenarios (i)

	Baseline Scenario H2025 average hydroelectric	Target Scenario H2025 average hydraulicity	Scenario Objective - Baseline H2030	
			Difference	%
DEMAND (TWh)	258	256	**-2**	*-0.8 %*
GENERATION GWh (%)	253 877	276 654	22 777	*9.0 %*
Nuclear	50 856	50 856	0	*0.0 %*
Inst. cap. (MW) Equiv. hours p.c.	*7 117 7 146*	*7 117 7 146*		
Coal	27 044	21 052	-5 992	*-22.2 %*
Inst. cap. (MW) Equiv. hours p.c.	*4 236 6 384*	*4 236 4 970*		
Combined cycle	20 366	5 538	-14 828	*-72.8 %*
P instal.(MW) Equiv. hours p.c.	*24 560 829*	*24 560 225*		
Hydroelectric power	31 982	32 258	276	*0.9 %*
Wind	71 796	86 545	14 749	*20.5 %*
P instal.(MW) Equiv. hours p.c.	*31 666 2 267*	*38 956 2 222*		
Solar PV	23 011	41 003	17 992	*78.2 %*
P instal.(MW) Equiv. hours p.c.	*12 784 1 800*	*22 784 1 800*		
Solar thermal	5 175	14 160	8 985	*173.6 %*
Other RES	6 700	7 950	1 250	*18.7 %*
Cogeneration and others	16 947	17 292	345	*2.0 %*
STORAGE BALANCE (GWh)	-320	-1 359	-1 039	
Consumption pumping and batteries	1 288	6 342	5 054	*392.4 %*
Production batteries	0	1 297	1 297	
Production pump	968	3 686	2 718	*280.8 %*
GENERATION RENEWABLES GWh	138 664	181 916	43 252	*31.2 %*
DISCHARGE RENEWABLES (GWh)	330	2 355	2 025	*613.6 %*
INTERCONNECTIONS				
Net balance (+ export from SPAIN)	-4 743	18 565	23 308	-
FRANCE	-11 150	8 134	19 284	-
PORTUGAL	6 407	10 431	4 024	-
Congestions *(%* hours)				
ES-FR	38 %	41 %	4 %	-
ES ->FR	12 %	28 %	17 %	-
FR ->ES	26 %	13 %	-13 %	**-**
ES-PT	1 %	5 %	5 %	-
ES ->PT	0 %	3 %	3 %	-
PT -> ES	0 %	2 %	2 %	**-**
AVERAGE SPREAD ES-FR (€/MWh)	5.7	10.3	4.6	*80.7 %*
INCOME CONGESTION SPAIN (€ m)	123	228	105	*85.4 %*

Table D.10 Comparative results of H2025 baseline and target scenarios (ii)

	Baseline Scenario *H2025* **average hydraulicity**	**Target Scenario** *H2025* **average hydraulicity**	**Scenario Target - Baseline H2030** **Difference**	*%*
SYSTEM COSTS				
Average marginal cost (€/MWh)	**63.1**	**53.0**	**-10.1**	**-16.0 %**
Cost variable generation (€/MWh)	**63.1**	**53.3**	**-9.3**	**-15.5 %**
Total yearly cost variable generation (€ bn)	**16.251**	**13.642**	**-2 609**	**-16.1 %**
EMISSIONS C0$_2$ (kt)	**43 137**	**32 324**	**-10 363**	**-25.2 %**
SHARE INDICATORS RES (%)				
RES/control	**54 %**	**71 %**	**17 %**	-
REVGen *total*	**55 %**	**66 %**	**11 %**	**-**

Average marginal cost (€/MWh): Demand weighted energy acquisition cost.

Variable generation cost (€/MWh): Cost of energy acquisition plus the cost of additional thermal generation necessary to reach the minimum dispatchable synchronous generation threshold.

Total annual cost variable generation (€ m) Total cost of energy acquisition plus the total cost of additional thermal generation.

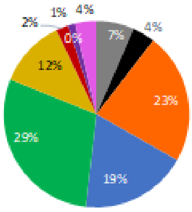
Figure D.4 Results of H2025 baseline scenario

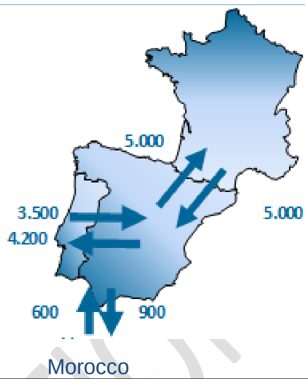
Baseline Scenario H2025. Energy Plan and Climate Change
Mainland Spain Minimum synchronous generation: 5500 *MW Cod021*

Demand in ES (TWh): 258	Peak demand (MW): 45 200

Mainland installed capacity (MW) **Exchange capacity (MW)**

	MW	%
Nuclear	7 117	7 %
Coal	4 236	4 %
Cycles	24 560	23 %
Hydroelectric (+ pumping)	20 140	19 %
Wind	31 566	29 %
Solar PV	12 784	12 %
Solar thermal	2 300	2 %
Solar thermal warehouse. 9h	0	0 %
Other RES	1 340	1 %
Cogeneration and others	4 020	4 %
Batteries	0	0 %
Total electricity system	108 163	100 %



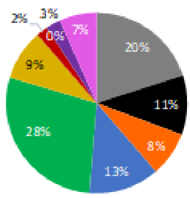


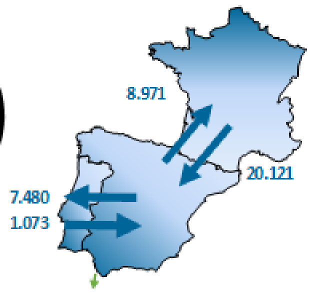
Additional information:

Generation without emissions in ES (MW)	*75 347*	*70 %*	*of the total electricity system*
*(Renewables (including pumping)*nuclear) RES in Mainland Spain (MW)*	*68 230*	*63 %*	*of the total electricity system*
RES in Portugal (MW)	*16681*	*77 %*	*of the total electricity system*
RES in Europe (%)	*60 %*	*Minimal synchronous thermal generation (MW): 5500*	

Generation balance (GWh). Mainland Spain **Balance for Yearly exchanges (GWh) |**

	GWIт	%	Hours utilisation
Nuclear	50 856	20 %	7 146
Coal	27 044	11 %	6 384
Cycles	20 366	8 %	S29
Hydroelectric power	31 982	13 %	1 588
Wind	71 796	28 %	2 267
Solar PV	23 011	9 %	1 800
Solar thermal	5 175	2 %	2 250
Solar thermal warehouse. 9h	0	0 %	0
Other RES	6 700	3 %	5 000
Cogeneration and others	16 947	7 %	4 216
Generation	253 878	100 %	
Storage balance	-320		
Storage consumption	*1 233*		
Pumping production	*963*		
Production batteries	*0*		





Export profile with Morocco: 0

Balance ES-FR	*-1 1150*	
Balance ES-PT:	*6 407*	
Net Balance + Morocco:	*4 743*	*ES IMPORT*
CONGESTION (% hours)	—▶	◀—
ES-FR	11.5 %	26.4 %
ES-PT	0.4 %	0.2 %
Spread ES-FR (E/MWtiE	5.7	

Additional information:

RES in Portugal (GWh)	*31 226*	*68 %*	*of elect. generation*	*60 % of demand*
RES in Spain (GWh)	*133 664*	*55 %*	*of elect. generation*	*54 % of demand*
RES in Europe (GWh)	*1 721 526*		*44 % of the total demand*	
CO_2 emissions of the generation mix (kton) (1):	*43 137*		*Congestion income (Mi):*	*123*

(1) ***includes emissions of the total of Cogeneration and others in accordance with information provided by MITECO.***

Discharges (GWh) **Energy not supplied (GWh)**

Spain	330	Spain	0	
	0.3 % of producible wind and solar		*0*	*Hours*

Costs in Spain

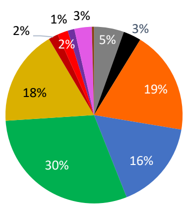
Variable cost (€/MWh):	*63.1*
Average marginal cost (i/MWh):	*63.1*
Other:	
Total min. sychronous generation cost (€ million)	*2*
Total annual Cost var generation(€ million):	*16.251*

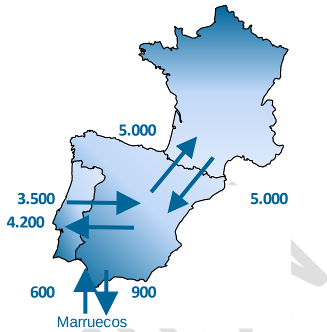
Figure D.5 Results of H2025 target scenario

Target Scenario H2025. Energy and Climate Change Plan			
Mainland Spain	Minimum synchronous generation:	5500 MW	***Code 019***
Demand in ES (TWh): 256	Peak demand (MW): 46 200		

Mainland installed capacity (MW) — **Exchange capacity (MW)**

	MW	%
Nuclear	7 117	5 %
Coal	4 236	3 %
Cycles	24 560	19 %
Hydroelectric (+ pumping)	21 260	16 %
Wind	38 956	30 %
Solar PV	22 784	18 %
Solar thermal	2 300	2 %
Solar thermal storage 9h	2 500	2 %
Other RES	1 590	1 %
Cogeneration and others	4 150	3 %
Batteries	500	0 %
Total electricity system	**129 953**	**100 %**





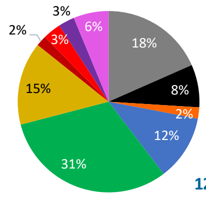
Additional information:

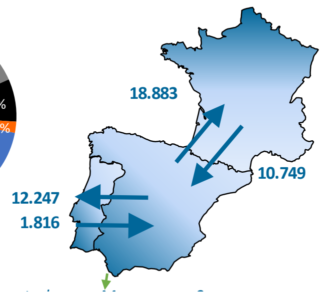
Generation without emissions in ES (MW)	***96 507***	***74 %***	***of the total electricity system***
(Renewables (including pumping)+nuclear)			
RES in mainland Spain (MW)	***89 390***	***69 %***	***of the total electricity system***
RES in Portugal (MW)	***16 681***	***77 %***	***of the total electricity system***
RES in Europe (%)	***60 %***	***Minimal synchronous thermal generation (MW):***	***5 500***

Generation balance (GWh). Mainland Spain — **Balance for Yearly exchanges (GWh) |**

	GWIT	%	Hours utilisation
Nuclear	50 856	18 %	7 146
Coal	21 052	8 %	4 969
Cycles	5 538	2 %	225
Hydroelectric power	32 258	12 %	1 517
Wind	86 545	31 %	2 222
Solar PV	41 003	15 %	1 800
Solar thermal	5 175	2 %	2 250
Solar thermal warehouse. 9h	8 985	3 %	3 594
Other RES	7 950	3 %	5 000
Cogeneration and others	17 292	6 %	4 167
Generation	253 878	100 %	
Storage balance		-1 359	

Storage consumption	6 342
Pumping production	*3 686*
Production batteries	*1 297*





Export profile with Morocco: 0		
Balance ES-FR	*8 134*	
Balance ES-PT:	*10 431*	
Net Balance + Morocco:	*18 565*	*ES EXPORT*
CONGESTION (% hours)	—▶	◀—
ES-FR	28.2%	13.2%
ES-PT	3.1%	2.1%
Spread ES-FR (E/MWtiE	10.3	

Additional information:

RES in Portugal (GWh)	***31 206***	***73 %***	***of generation of Elec.***	***60 % of demand***
RES in Spain (GWh)	***181 916***	***66 %***	***of generation of Elec.***	***71 % of the demand***
RES in Europe (GWh)	***1 770 239***		***45 % of the total demand***	

CO_2 emissions of the generation mix ***111*: 32 324** ***(Kton)*** — ***Congestion income (€ m):*** ***228***

(1) includes emissions of the total Cogeneration and others in accordance with information provided by MITECO.

Discharges (GWh)			**Energy not supplied (GWh)**	
Spain	2 355		**Spain**	0
	1.6 %	***of the producible wind and solar***		***0 Hours***

Costs in Spain

Variable Cost (€/MWh): ***53.3***

Average marginal cost (€/MWh): ***53.0***

Other:

Total min. sychronous additional generation cost (€m) ***68***

Total annual Cost var generation(€m): ***13.642***

RESULTS OF 2030 HORIZON SCENARIOS

The complete results of the simulations of the 2030 baseline and target scenarios are presented in 0 and 0 respectively. A comparison of the results obtained for the 2030 baseline and target scenarios is provided in 0 and Table D.12.

Table D.11 Comparative results of H2030 baseline and target scenarios (i)

	Baseline Scenario H2030 average hydraulicity	Target Scenario H2030 average hydraulicity	Scenario Target - Baseline H2030	
			Difference	%
DEMAND (TWh)	**263**	**268**	**5**	*1.3 %*
GENERATION GWh (%)	**271 521**	**310 593**	**39 072**	*14.4 %*
Nuclear	**50 868**	**21 846**	**-29 022**	*-57.1 %*
Inst. capacity (MW) Equiv. hours p-C.	*7 117 7 147*	*3 050 7 163*		
Coal	**22 972**	**0**	**-22 972**	*-100.0 %*
Inst. capacity (MW) Equiv. hours p.c.	*4 236 5 423*	*0 0*		
Combined cycle	**25 218**	**34 043**	**8 825**	*35.0 %*
Inst. capacity (MW) Equiv. hours p-C.	*24 560 1 027*	*24 560 1 386*		
Hydroelectric power	**31 982**	**32 257**	**275**	*03 %*
Wind	**86 507**	**108 013**	**21 506**	*24.9 %*
Inst. capacity (MW) Equiv. hours p.c.	*36 290 2 384*	*48 580 2 223*		
Solar PV	**31 734**	**64 718**	**32 984**	*1 033 %*
Inst. capacity (MW) Equiv. hours p.c.	*17 634 1 800*	*36 134 1 791*		
Thermal solar	**5 175**	**23 047**	**17 872**	*345.4 %*
Other RES	**6 700**	**11 011**	**4 311**	*64.3 %*
Cogeneration and others	**10 365**	**15 658**	**5 293**	*51.1 %*
STORAGE BALANCE (GWh)	**-670**	**-3 608**	**-2 938**	
Consumption pumping and batteries	**2 703**	**18 611**	**15 908**	*588.5 %*
Production batteries	**0**	**6 103**	**6 103**	
Production pumping	**2 033**	**8 900**	**6 867**	*337.8 %*
GENERATION RENEWABLES GWh	**162 099**	**239 136**	**77 037**	*473 %*
DISCHARGE RENEWABLES (GWh)	**571**	**7 734**	**7 163**	*12 543 %*
INTERCONNECTIONS				
Net balance (+ export from SPAIN)	**7 846**	**39 553**	**31 707**	-
FRANCE	**-1 700**	**27 108**	**28 808**	-
PORTUGAL	**9 546**	**12 445**	**2 899**	-
Congestions (% hours)				
ES-FR	**20 %**	**29 %**	**9 %**	-
ES->FR	**12 %**	**27 %**	**14 %**	-
FR ->ES	**8 %**	**3 %**	**-5 %**	-
ES-FT	**2 %**	**5 %**	**3 %**	**-**
ES->PT	**1 %**	**5 %**	**3 %**	**-**
PT-> ES	**0 %**	**0 %**	**0 %**	**-**
AVERAGE SPREAD ES-FR (€/MWh)	**4.2**	**10.5**	**6.3**	*150.0 %*
INCOME CONGESTION SPAIN (€ m)	**147**	**3 66**	**219**	*149.0 %*

Table D.12 Comparative results of H2030 baseline and target scenarios (i)

	Baseline Scenario H2030 average hydraulicity	Target Scenario H2030 average hydraulicity	Scenario Target - Baseline H2030 Difference	%
SYSTEM COSTS				
Average marginal cost (€/MWh)	**69.7**	**56.8**	**-12.9**	**-18.5 %**
Cost variable generation (€/MWh)	**69.8**	**62.4**	**-7.4**	**-10.6 %**
Total yearly cost variable generation (€ bn)	**18 355**	**16 681**	**-1 674**	**-9.1 %**
EMISSIONS CO_2 (kt)	**37 170**	**21 055**	**-16 115**	**-43.4 %**
SHARE INDICATORS RES (%)				
RES/demand	**62 %**	**89 %**	**28 %**	**-**
RES/Gen total	**60 %**	**77 %**	**17 %**	**-**

Average marginal cost (€/MWh): Demand weighted energy acquisition cost.

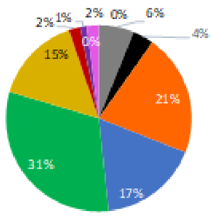
Variable generation cost (€/MWh): Cost of energy acquisition plus the cost of additional thermal generation necessary to reach the minimum dispatchable synchronous generation threshold.

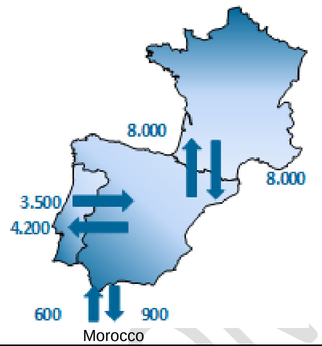
Total annual cost variable generation (€ m) Total cost of energy acquisition plus the total cost of additional thermal generation.

Figure D.6 Results of H2030 baseline scenario

Baseline Scenario H2030. Energy Plan and Climate Change Mainland	**Spain** Minimal synchronous generation:	5500 MW	*Code 020*
Demand in ES (TWh): 263	Peak demand (MW): 48 652		

Mainland installed capacity (MW)				**Exchange capacity (MW)**
		MW	%	
Nuclear		7 117	*m*	
Coal		4 236	*4 %*	
Cycles		24 560	*21 %*	
Hydroelectric (+ pumping)		20 140	*17 %*	
Wind		*36 290*	3136	
Solar PV		17 634	1536	
Solar thermal		2 300	236	
Solar thermal storage 9h		0	036	
Other RES		1 340	136	
Cogeneration and others		2 400	236	
Batteries		0	036	
Total electricity system		116 017	100 %	

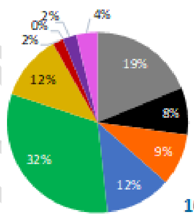


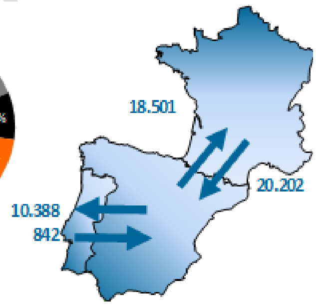


Additional information:

Generation without emissions in ES (MW)	*84 821*	*73 %*	*of the total electricity system*
(Renewables (including pumping) + nuclear) RES in Mainland Spain (MW)	*77 704*	*67 %*	*of the total electricity system*
RES in Portugal (MW)	*22239*	*81 %*	*of the total electricity system*
RES in Europe (%)	*71 %*	*Minimal synchronous thermal generation (MW): 5 500*	

Generation balance (GWh). Mainland Spain					**Balance for Yearly exchanges (GWh)**
		GWh	%	Hours utilisation	
Nuclear		50 868	1 936	7 147	
Coal		22 972	836	5 423	
Cycles		25 218	936	1 027	
Hydroelectric power		31 982	1 296	1 588	
Wind		86 507	3 236	2 384	
Solar PV		31 734	1 296	1 800	
Solar thermal		5 175	236	2 250	
Solar thermal storage 9h		0	036	0	
Other RES		6 700	236	5 000	
Cogeneration and others		10 365	436	4 319	
Generation		271 522	100 %		





Storage balance	-671
Storage consumption	*2703*
Pumping production	*2033*
Production batteries	*0*

Export profile with Morocco: 0

Balance ES-FR	*-1 700*	
Balance ES-PT:	*9 546*	
Net Balance + Morocco:	*7 345*	*ES EXPORT*
CONGESTION (% hours)	—▶	◀—
ES-FR	12 %	8.0 %
ES-PT	1.4%	0.2 %
Spread ES-FR (E/MWtiE	4.2	

Additional information.

RES in Portugal (GWh)	*40 611*	*80 %*	*of elect. generation*	*68 %*	*of demand*
RES in Spain (GWh)	*162 099*	*60 %*	*of elect. generation*	*62 %*	*of demand*
RES in Europe (GWh)	*2 206 793*		*54 % of total demand*		
CO_2 emissions of the generation mix (kton) [(1)]:	*37 170*		*Congestion income (€m):*	*147*	

[(1)] ***includes emissions of the total Cogeneration and others in accordance with information provided by MITECO.***

Discharges (GWh)			**Energy not supplied (GWh)**		
Spain	571		Spain	0	
	0.5 %	*of the producible wind and solar*		*0*	*Hours*

Costs in Spain	
Variable Cost (€/MWh):	*69.8*
Average marginal cost (€/MWh):	*69.7*
Other:	
Total min. sychronous additional generation cost (€m)	*19*
Total annual Cost var generation(€ bn):	*18 355*

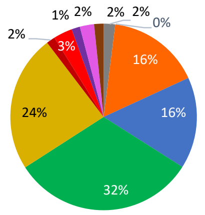
Figure D.7 Results of H2030 target scenario

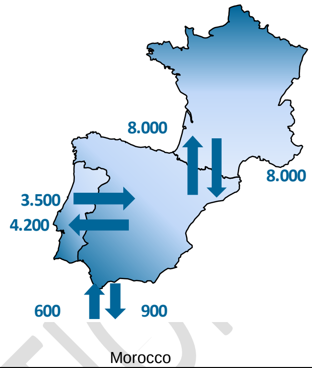
Target Scenario H2030. Energy Plan and Climate Change **Mainland Spain**	Minimum synchronous generation:	5 500 MW	***Code 018***

Demand in ES (TWh): 268 | Peak demand (MW): 48 652

Mainland installed capacity (MW) | **Exchange capacity (MW)**

	MW	%
Nuclear	*3 050*	2 %
Coal	0	0 %
Cycles	24 560	16 %
Hydroelectric (+ pumping)	24 140	16 %
Wind	*48 580*	32 %
Solar PV	36 134	24 %
Solar thermal	2 300	2 %
Solar thermal storage 9h	5 000	3 %
Other RES	2 220	1 %
Cogeneration and others	3 750	2 %
Batteries	2 500	2 %
Total electricity system	**152 234**	**100 %**



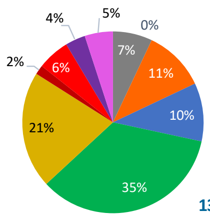


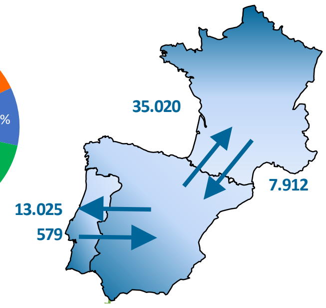
Additional information:

Generation without emissions in ES (MW) 121 424	***80 %***	***of the total electricity system***
(Renewables (including pumping)+nuclear) ***RES in mainland Spain (MW) 118 374 RES in Portugal (MW) 22 239***	***78 %*** ***81 %***	***of the total electricity system of the total electricity system***
RES in Europe (%) 72 %	***Minimal synchronous thermal generation (MW): 5 500***	

Generation balance (GWh). Mainland Spain | **Balance for yearly exchanges (GWh)**

	GWh	%	Hours utilisation
Nuclear	21 846	7 %	7 162
Coal	0	0 %	0
Cycles	34 043	11 %	1 386
Hydroelectric power	32 257	10 %	1 336
Wind	108 013	35 %	2 223
Solar PV	64 718	21 %	1 791
Solar thermal	5 160	2 %	2 243
Solar thermal storage 9h	17 887	6 %	3 577
Other RES	11 100	4 %	5 000
Cogeneration and others	15 658	5 %	4 175
Generation	**310 683**	**100 %**	





Storage balance	**-3 609**
Storage consumption	***18 611***
Production pumping	***8 900***
Production batteries	***6 103***

Export profile with Morocco: 0

Balance ES-FR	***27 108***	
Balance ES-PT:	***12 445***	
Net Balance + Morocco:	***39 554***	***ES EXPORT***
CONGESTION (% hours)	—►	◄—
ES-FR	26.5 %	2.9 %
ES-PT	4.8 %	0.1 %
Spread ES-FR (€/MWh):	***10.5***	

Additional information:

RES in Portugal (GWh)	***40 506***	***84 %***	***of generation of Elec.***	***68 % of the demand***
RES in Spain (GWh)	***239 136***	***77 %***	***of generation of Elec.***	***89 % of the demand***
RES in Europe (GWh)	***2 283 394***		***56 % of the total demand***	
CO_2 emissions of the generation mix (kton) (1):	***21 055***		***Congestion income (€ m):***	***366***

(1) includes emissions of the total Cogeneration and others in accordance with information provided by MITECO.

Discharges (GWh) | **Energy not supplied (GWh)**

España 7 734 | Spain 0

3.8 % of the producible wind and solar | ***0 Hours***

Costs in Spain

Variable Cost (€/MWh):	***62.4***
Average marginal cost (€/MWh):	***56.8***
Others:	
Total min. sychronous additional generation cost (€m):	***1 489***
Total annual Cost var generation (€m):	***16 681***

ANNEX E. CONTRIBUTION OF THE PLAN TO THE SUSTAINABLE DEVELOPMENT GOALS OF AGENDA 2030

On 29 June 2018, at the proposal of the High Level Group for Agenda 2030, the Council of Ministers approved the ‘Action Plan for the Implementation of Agenda 2030: Towards a Spanish Strategy for Sustainable Development’. This plan highlights Spain's commitment to Agenda 2030 and the need for it to be a reference for all public policies.

The plan also highlights climate change as an additional challenge in meeting other Sustainable Development Goals (SDGs) such as those related to water, underwater life or terrestrial ecosystems (6, 14, 15), as well as the cross-cutting nature of measures to combat it, which allows synergies with all the goals. In this regard, the degree to which the different measures considered in the Integrated National Energy and Climate Plan contribute to the different SDGs has been analysed.

SDG 7 and 13 (affordable and non-polluting energy and climate action) are the central objectives of the plan, and the following interactions with other SDGs also stand out:

The global and cross-cutting nature of the fight against climate change requires alliances and coordination in all respects, both between the public and private sectors and at local, regional, national and international levels.

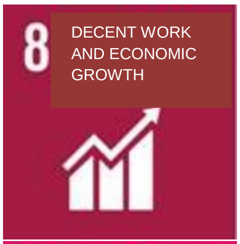
The existence of concurrent competences between different levels of administration, the importance of the active involvement of the private sector, and the weight of the European and international context in the field of energy and the climate, are factors that make it necessary to develop cooperation mechanisms that will make it possible to achieve the objectives.

Innovation, both in the development of new technologies and solutions, and in the adequate application of existing ones, has a special preponderance in this Plan, beyond the specific dimension of research, innovation and competitiveness.

In order to meet the objectives of this plan, the industrial sector is also key. Consequently, several measures aimed at improving competitiveness and reducing emissions from this sector are included.

An important part of the measures to be deployed focus on the urban sphere, from upgrading to improve the energy efficiency of the residential or tertiary sectors, to the promotion of cleaner and more efficient modes or technologies of transport. At the same time, reducing emissions and improving efficiency also require greater responsibility on the part of consumers, for whom it needs to be made easier to choose more sustainable alternatives.

On the other hand, the plan encourages the development of self-consumption and local energy communities, and ultimately greater citizen participation in the energy sector.



The Plan is expected to generate an increase in GDP of between 19 300 and 25 100 million euros per year and an increase in employment of between 250 000 and 364 000 people per year, an area in which the construction and services sectors stand out, due to investment in the energy upgrading of buildings and new investments linked to the change of model. In addition, some of the measures contain specific criteria for exploiting their job creation potential or their role in just transition.

The analysis also reveals that the measures favour low-income households and especially vulnerable groups, although specific measures have also been included in the area of consumer protection and the fight against energy poverty. In addition, some measures are aimed at reducing inequalities between territories in terms of access to energy.

The table below summarises the specific contribution of the various measures envisaged in the plan to the SDGs.

Table E.1 Interactions between the INECP and the SDGs

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Decarbonisation	1.1 New renewables capacity																	
	1.2 Integration of renewables in networks																	
	1.3 Self-consumption and distributed generation																	
	1.4 Industrial sector																	
	1.5 Thermal renewables																	
	1.6 Advanced biofuels in transport																	
	1.7 Renewable gases																	
	1.8 Renewal of existing projects																	
	1.9 Bilateral contracting of renewables																	
	1.10 Exploitation of biomass																	
	1.11 Administrative processes																	
	1.12 Knowledge, dissemination, awareness, training																	
	1.13 Unique projects and sustainable energy on islands																	
	1.14 Agricultural and livestock sectors																	
	1.15 Waste management																	
	1.16 Fluorinated gases																	
	1.17 Forest sinks																	
	1.18 Agricultural sinks																	
	1.19 ETS System																	
	1.20 Taxation																	
Energy efficiency	2.1 Technology and industrial process management																	
	2.2 Modal change in mobility																	
	2.3 More efficient use of the means of transport																	
	2.4 Renewal of vehicle fleet																	
	2.5 Promotion of the electric vehicle																	
	2.6 Energy efficiency in the residential sector																	
	2.7 Renewal of residential equipment																	
	2.8 Energy efficiency in the construction of the tertiary and public sector																	
	2.9 Cooling and air conditioning in large installations in the tertiary or public sector																	
	2.10 Farms, irrigation communities and agricultural machinery																	
	Promotion of energy services																	
	Public sector: proactive responsibility and energy-efficient public procurement																	
	Energy audits and management systems																	
	Communication, information and training																	
	Transition in high efficiency cogeneration																	
Security	3.1 Reduction of oil dependency of islands																	
	3.2 Alternative fuel recharge points			1														
	3.3 Regional cooperation																	
	3.4 Contingency plans																	
Domestic market	4.1 Increased electricity interconnection with France																	
	4.2 Increased electricity interconnection with Portugal																	
	4.3 Transport infrastructure																	
	4.4 Integration of the electricity market																	
	4.5 Consumer protection and improvement of competitiveness																	
	4.6 Integration of the gas market																	
	4.7 Protection of gas consumers																	
	4.8 Competitiveness of the retail gas sector																	
	4.9 Gas demand management																	
	4.10 Fight against energy poverty																	
Research, innovation and competitiveness	5.1 Strategic action on energy and climate																	
	5.2 SET-Plan																	
	5.3 Network of centres of excellence																	
	5.4 Infrastructure and scientific and technological equipment																	
	5.5 Public procurement in green innovation																	
	5.6 Energy City (CIUDEN)																	
	5.7 Information System																	
	5.8 European innovation financing mechanisms																	
	5.9 International cooperation																	
	Totals	5	0	10	7	2	5	46	17	34	19	22	27	40	1	8	11	36