European Commission

EU Reference Scenario 2016

Energy, transport and GHG emissions
Trends to 2050
Main results

This publication was prepared on the basis of the “EU Reference Scenario 2016 – Energy, transport and GHG emissions - Trends to 2050” publication report.

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Main results

EUROPEAN COMMISSION

Directorate-General for Energy, Directorate-General for Climate Action and
Directorate-General for Mobility and Transport

1. INTRODUCTION

This summary highlights the main results of the EU Reference scenario 2016 (REF2016)[1]. REF2016 projects EU and Member States energy, transport and greenhouse gas (GHG) emission-related developments up to 2050. It does so by taking into account global and EU market trends and the energy and climate policies already adopted by the EU and its Member States.

The projections are based on a set of assumptions, including on population growth, macroeconomic and oil price developments, technology improvements, and policies. Regarding policies, projections show the impacts of the full implementation of existing legally binding 2020 targets and EU legislation. As such, they also show the continued impact post 2020 of policies such as the EU Emissions Trading System Directive (including the Market Stability Reserve), the Energy Performance of Buildings Directive, Regulations on ecodesign and on CO_2 emission standards for cars and vans, as well as the recently revised F-gas Regulation. Such policies notably influence current investment decisions, with impacts on the stock of buildings, equipment and cars, which have long-lasting effects post-2020 on GHG emissions or energy consumption.

REF2016 provides a consistent approach in projecting long term energy, transport and climate trends across the EU and is a key support for policy making. However, it is not a forecast since, as with any such exercise, there are several unknowns. These range from macroeconomic growth, fossil fuel prices, technological costs, and the degree of policy implementation across EU. Moreover, REF2016 does not include the politically agreed but not yet legally adopted 2030 climate and energy targets.

The main results are as follows:

- Despite a projected decrease in EU fossil fuel production, net fuel imports will decrease and the EU's import dependency will only slowly increase over the projected period. That is mainly due to the higher share of renewable energy sources (RES) and significant energy efficiency improvements, while nuclear production remains stable.
- The EU power generation mix will change considerably in favour of renewables. Gas maintains its role in the power generation mix in 2030, at slightly higher levels compared to 2015, but other fossil fuels will see their share decrease.
- There will be significant energy efficiency improvements, driven mainly by policy up to 2020 and then by market/technology trends post-2020. Primary energy demand and GDP will continue to decouple.
- Transport activity shows significant growth, with the highest increase during 2010-2030, driven by developments in economic activity. The decoupling between energy consumption and activity is projected to continue and even to intensify in the future.

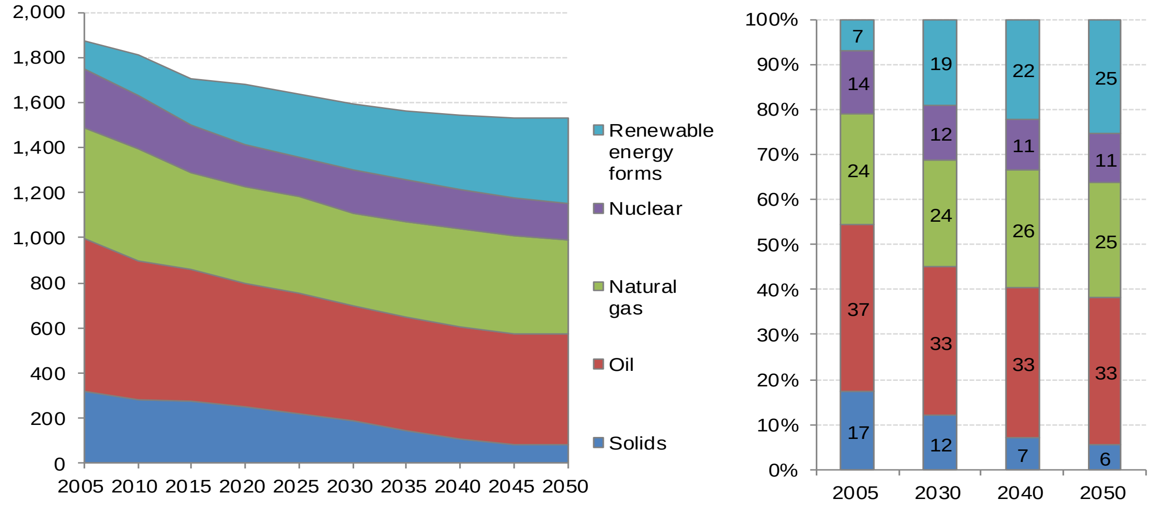
[1] The "EU Reference Scenario 2016 – Energy, transport and GHG emissions - Trends to 2050" publication report describes in detail the analytical approach followed, the assumptions taken and the detailed results.

- Decarbonisation of the energy system progresses, but falls short of agreed longer term climate objectives. Total GHG emissions are projected to be 26% below 1990 levels in 2020, 35% below by 2030 and 48% by 2050. The share of renewables in the energy mix will continue to grow, from 21% in 2020 to 24% in 2030 and 31% in 2050.
- Non-CO_2 emissions decrease until 2030 even more strongly than CO_2 emissions, by 29% below 2005 levels in 2030 (-46% compared to 1990 levels). The net sink provided by the land use, land use change and forestry sector declines from -299 Mt CO_2 eq. in 2005 to -288 Mt CO_2-eq in 2030, mainly with the sink in existing forests decreasing, but partly compensated by other activities such as afforestation.
- Energy-related investment expenditures increase substantially until 2020, driven by RES and energy efficiency developments. Overall energy system costs increase from 11.2% of EU GDP in 2015 to about 12.3% of EU GDP by 2020, also driven by projected rising fossil fuel prices. They stabilise at such levels until 2030, and decrease thereafter, reaping the benefits of the investments made.

2. ENERGY SECURITY

Figure 1 presents the projected evolution of EU Gross Inland Energy Consumption. After the 2005 peak, energy consumption is projected to steadily decline until 2040, where it stabilises. Oil still represents the largest share in the energy mix, mostly because of transport demand. Solid fuels see a significant reduction in their share of the energy mix, while the biggest increase is for renewable energy. Natural gas and nuclear energy keep relatively stable shares in the energy mix.

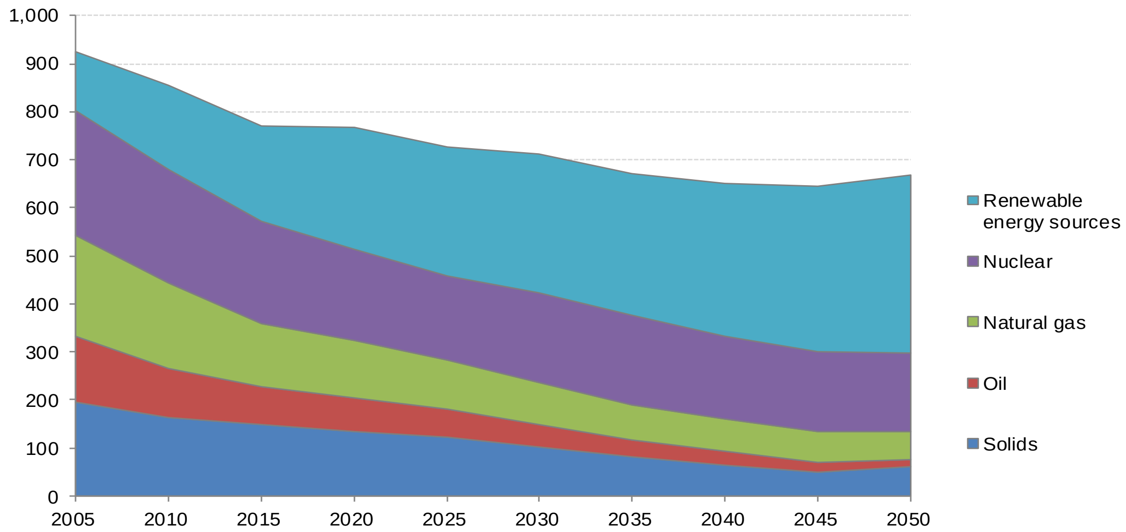
Figure 1: EU28 Gross Inland Consumption (Mtoe, left; shares (%), right)



Source: PRIMES

EU energy production (Figure 2) is projected to continue to decrease from around 760 Mtoe in 2015 to around 660 Mtoe in 2050. The projected strong decline in EU domestic production for all fossil fuels (coal, oil and gas) coupled with a limited decline in nuclear energy production is partly compensated by an increase in domestic production of renewables. Biomass and biowaste will continue to dominate the fuel mix of EU domestic renewable production, although the share of solar and wind in the renewable mix will gradually increase from around 17% in 2015 to 36% in 2050.

Figure 2: EU energy production (Mtoe)



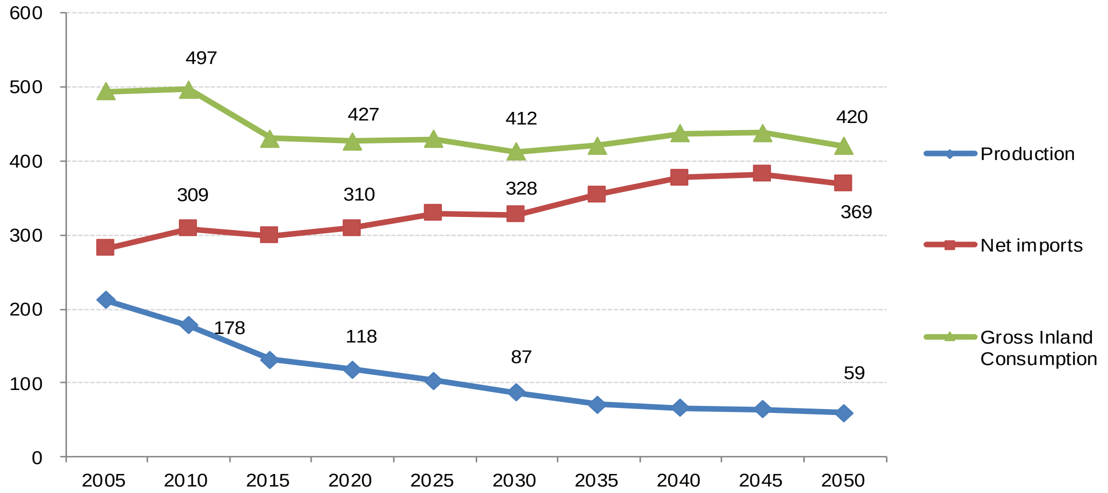
Source: PRIMES

EU's import dependency shows a slowly increasing trend over the projected period, from 53% in 2010 to 58% in 2050. RES deployment, energy efficiency improvements and nuclear production (which remains stable) counteracts the strong projected decrease in EU's fossil-fuel production.

Solid imports as well as crude oil and (refinery) feedstock decline throughout the projection period, while oil products imports slightly increase. Natural gas imports increase slightly in the long term reaching approximately 370 bcm[2] net imports in 2050. Biomass remains mostly supplied domestically, although the combination of increased bioenergy demand and limited potential for additional EU domestic supply leads to some increases in biomass imports post-2020 (from 11% of biomass demand in 2020 to about 15% in 2030 and beyond).

Up to 2020, the consumption of gas is expected to remain stable at around 430 bcm in gross inland terms. Post 2020, a slight decrease in gross inland consumption of gas (412 bcm in 2030) is projected, as well as further reductions in indigenous production of gas (Figure 3). Net import dependency of natural gas registers an increase as domestic gas production continues its downward trend. The imported volumes of gas are projected to increase between 2015 and 2040 and then to stabilise in the long term, 15% above the 2010 net import level (from 309 bcm in 2010 to 369 bcm in 2050).

Figure 3: Gas - production, net imports and demand (volumes expressed in bcm)



Source: PRIMES

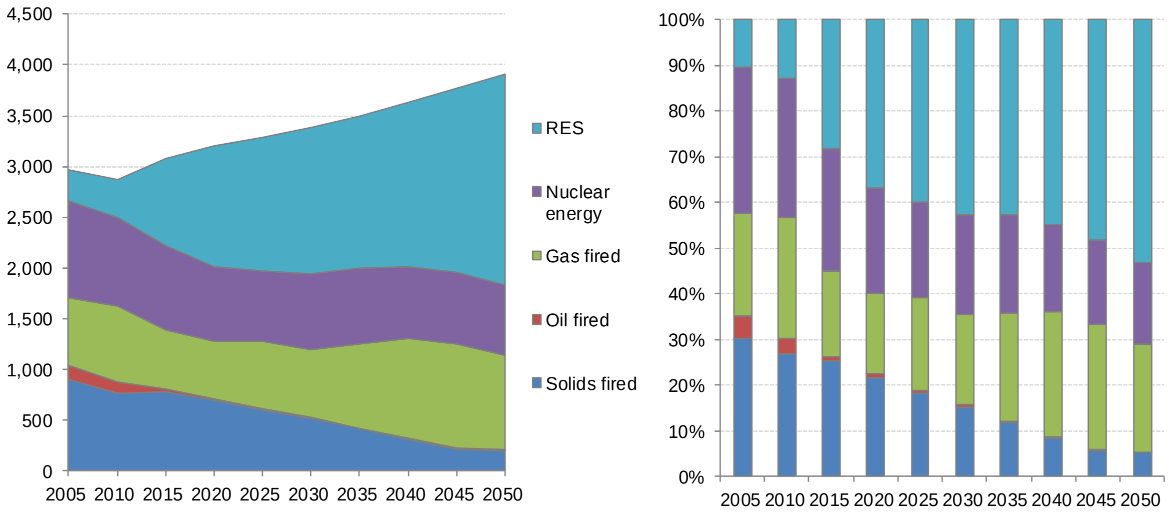
[2] The conversion rate of 1 Mtoe = 1.11 bcm was used for natural gas, based on the BP conversion calculator.

3. INTERNAL ENERGY MARKET AND INVESTMENTS

The EU power generation mix changes considerably over the projected period in favour of renewables (Figure 4). Before 2020, this occurs to the detriment of gas, as a strong RES policy to meet 2020 targets, very low coal prices compared to gas prices, and low CO_2 prices do not help gas to replace coal. After 2020, the change is characterised by further RES deployment, but also a larger coal to gas shift, driven mainly in anticipation of increasing CO_2 prices.

Gas therefore maintains its presence in the power generation mix in 2030 (at slightly higher levels in the long term compared to 2015). The share of solids/coal in power generation significantly declines, but not before 2020, to 15% in 2030.

Figure 4: EU power generation (net) by fuel (Mtoe – left, shares – right)



Source: PRIMES

Variable RES (solar and wind) reach around 19% of total net electricity generation in 2020, 25% in 2030 and 36% in 2050, demonstrating the growing need for flexibility in the power system. Wind onshore is expected to provide the largest contribution. Solar PV and biomass also increase over time. Hydro and geothermal remain roughly constant. The share of nuclear decreases gradually over the projected period despite some life time extensions and new built, from 27% in 2015 to 22% in 2030.

REF2016 shows increasing volumes of electricity trade over time. The flow between regions increases from 17% in 2015 to 26% in 2020, 29% in 2030 and then stays almost stable for the remainder of the projection period reaching 30% in 2050. Main drivers are intermittent RES power generation and the resulting balancing requirements. Trade is facilitated by the assumed successful development of the ENTSO-E Ten-Year Network Development Plan 2014[3] as well as pan-European market coupling and sharing of reserves and flexibility across Member States.

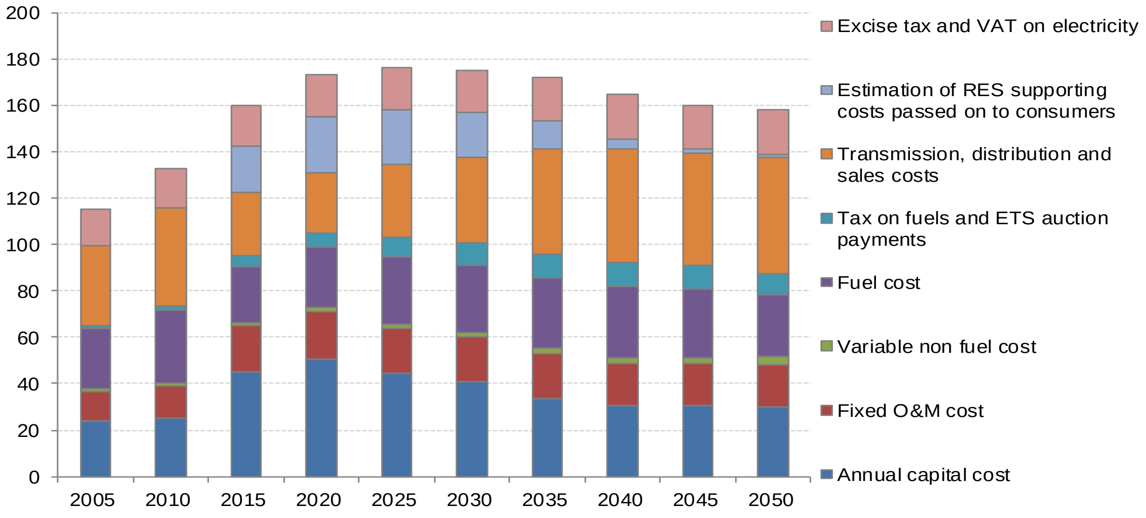
Average retail electricity prices[4] (Figure 5) steadily increase up to 2030 by about 18% relative to 2010 levels, stabilising around 20% during 2030-2040, after which they start to gradually decrease. The structure of electricity costs changes over time, with the capital cost

3 Source: https://www.entsoe.eu/major-projects/ten-year-network-development-plan/ten%20year%20network%20development%20plan%202016/Pages/default.aspx

4 In the PRIMES model, prices differ per type of end-user.

component (generation and grid costs) increasing significantly in the short term up to 2020, but decreasing afterwards in the longer term. From 2030, the fuel cost component remains stable despite the increase in fuel prices, due to a decreasing share of fossil-fuel combustion. Transmission and distribution costs increase significantly in the longer term, post-2030, partly linked to the need to cater for the increased presence of RES in the power generation mix.

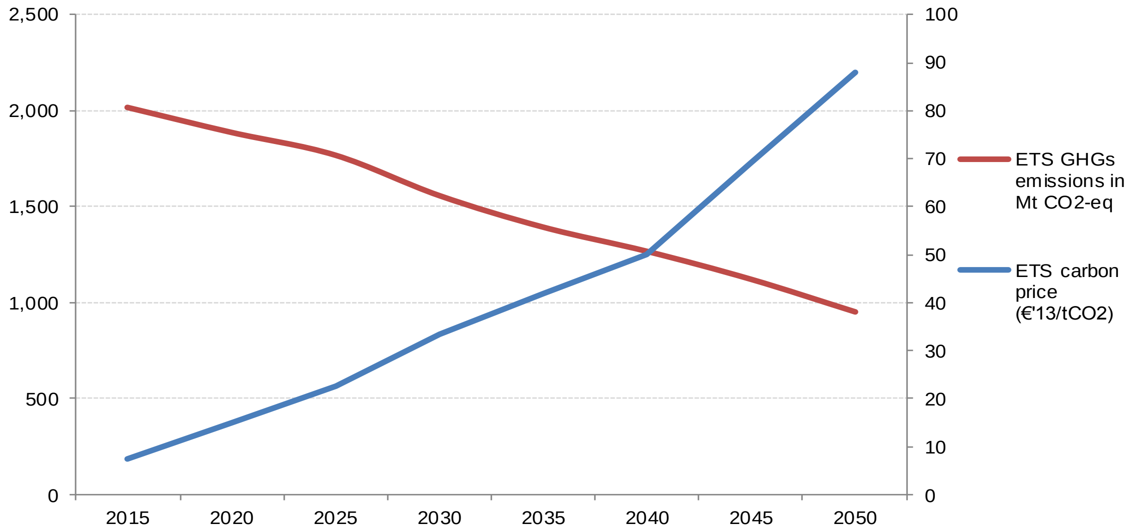
Figure 5: Decomposition of electricity generation costs and prices (€'2013 MWh)



Source: PRIMES

As a result of the modelling, the carbon price is projected to increase (Figure 6), reflecting both the steadily decreasing ETS cap and the stabilising effect of the Market Stability Reserve. However, the increase in electricity prices due to ETS remains limited despite the significant increase in CO_2 price, as the share of carbon-intensive power generation decreases.

Figure 6: ETS emissions and carbon prices over time

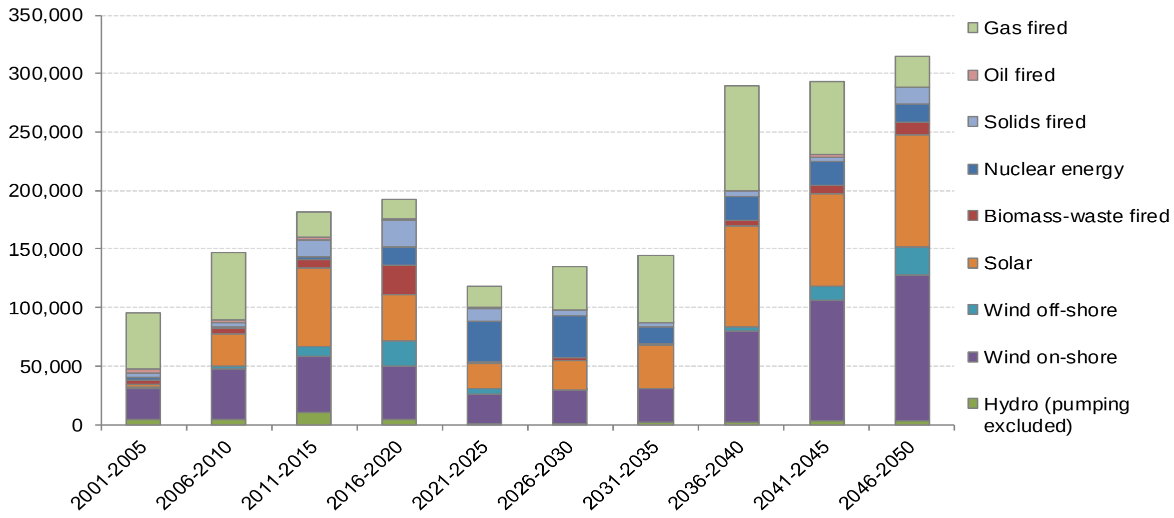


Source: PRIMES, GAINS

Electricity prices for households and services are projected to increase moderately in the medium term and to decrease slightly in the long term. Prices for industry on the contrary are stable or decrease over time as energy intensive industry maintains an electricity demand profile compatible with base-load power generation and bears a small fraction of grid costs and taxes. Taxes apply mainly on prices for households and services.

Investment expenditures for power supply (Figure 7) increase substantially until 2020 driven by RES targets and developments, but slow down thereafter, until 2030, before increasing again from 2030 onwards notably due to increasing ETS carbon prices reflecting a continuously decreasing ETS cap based on the current linear factor. New power plant investment is dominated by RES, notably solar PV and wind onshore. Nuclear investment mostly takes place via lifetime extensions until 2030 and in the longer term via new built, such as projected in, for instance, the UK, Finland, Sweden, France, Poland, and other Central European Member States. New thermal plant investment is mainly taking place in gas-fired plants.

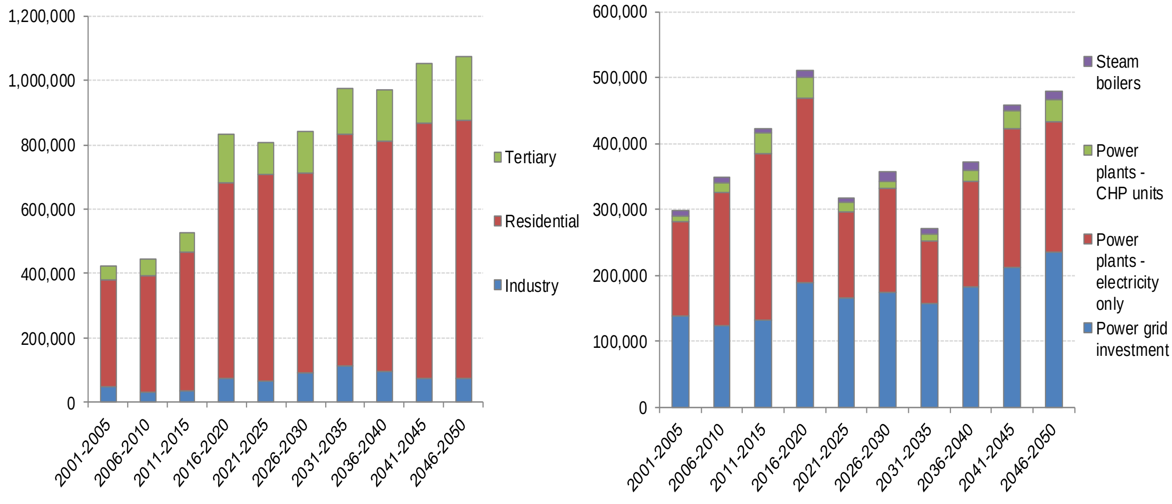
Figure 7: Net power capacity investments by plant type (MWh – for five year period)



Source: PRIMES

Investment expenditures in demand sectors (Figure 8 – left hand side) over the projected period will be higher than in the past. They notably peak in the short term up to 2020, particularly in the residential and tertiary sectors, as a result of energy efficiency polices. Post-2020 they slightly decline until 2030, before increasing again to 2050. On the supply side (Figure 8 – right hand side), investments peak towards 2020, followed by a decrease, notably explained by a decline in power generation investments.

Figure 8: Investment expenditures (5-year period) - demand side, million €'2013 (left, excluding transport) and supply side, million €'2013 (right)



Source: PRIMES

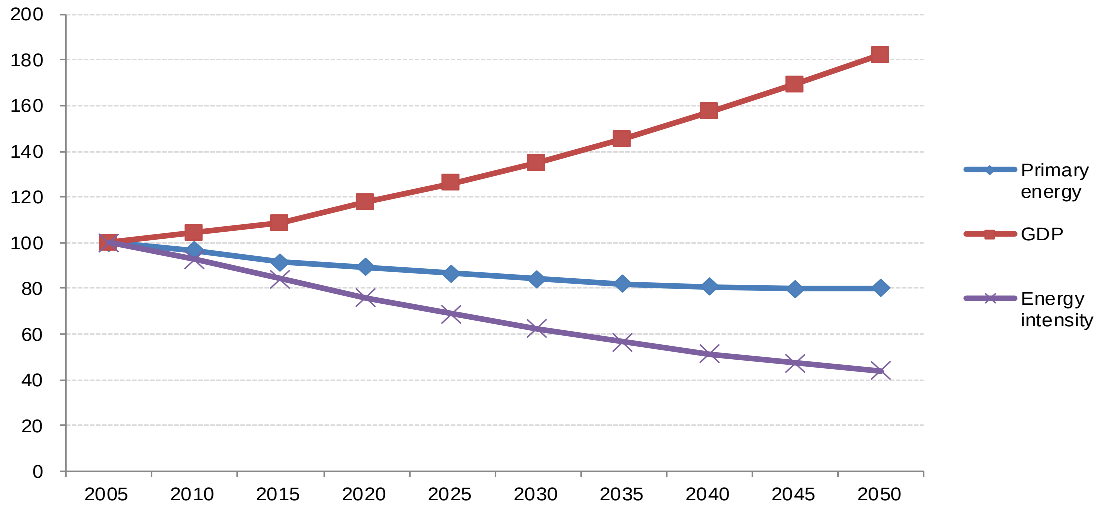
Transport investments (expenditures related to transport equipment) steadily increase over time but maintain a relatively stable share of GDP (i.e. between 4% and 4.5% of GDP throughout the projection period). The relative weight of energy-related spending in households' expenditure[5] increases in 2020 compared to 2015 (7.5% compared to 6.8%), stabilising until 2030 before decreasing again until 2050 (6.1%).

[5] Share of energy system costs for the residential sector (fuel costs and annualised capital costs of energy related investment expenditures) in total households' consumption

4. MODERATION OF ENERGY DEMAND

In 2020, primary energy consumption decreases by 18.4% (relative to the 2007 baseline, i.e. how the energy efficiency (EE) target is defined), more than the sum of national Member States' indicative energy efficiency targets but still falling slightly short of the 2020 indicative EU energy efficiency target of 20%. In 2030, energy consumption is projected to decrease (again relative to 2007 baseline projections) by 23.9%. Primary energy demand and GDP continue to decouple (Figure 9), which is consistent with the trends observed since 2005. Energy efficiency improvements are mainly driven by policy up to 2020 and by market/technology trends after 2020.

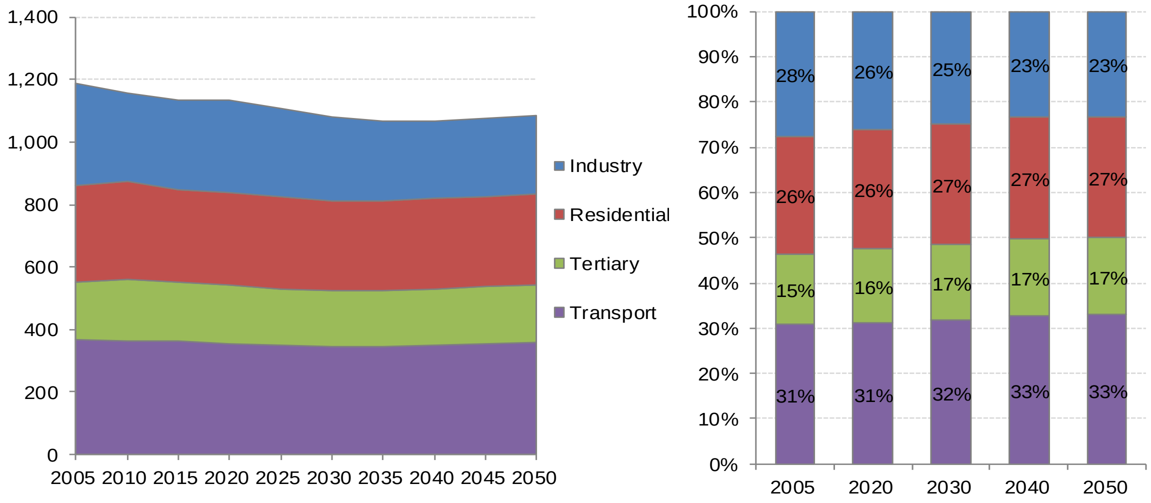
Figure 9: Decoupling of EU energy use and intensity from GDP (2005=100)



Source: Commission calculations based on PRIMES and GEM-E3

The distribution of final energy consumption across sectors (Figure 10) remains broadly similar to the current picture, all the way to 2050, with transport and the residential sector comprising the lion's share of final energy consumption (32% and 27% of final consumption, respectively, in 2030). Industry sees its share in final energy demand decreasing, from 28% in 2005 to 23% in 2050, mostly due to improved energy efficiency in non-energy intensive industries. The tertiary (services and agriculture) sector keeps a stable share of about 17%.

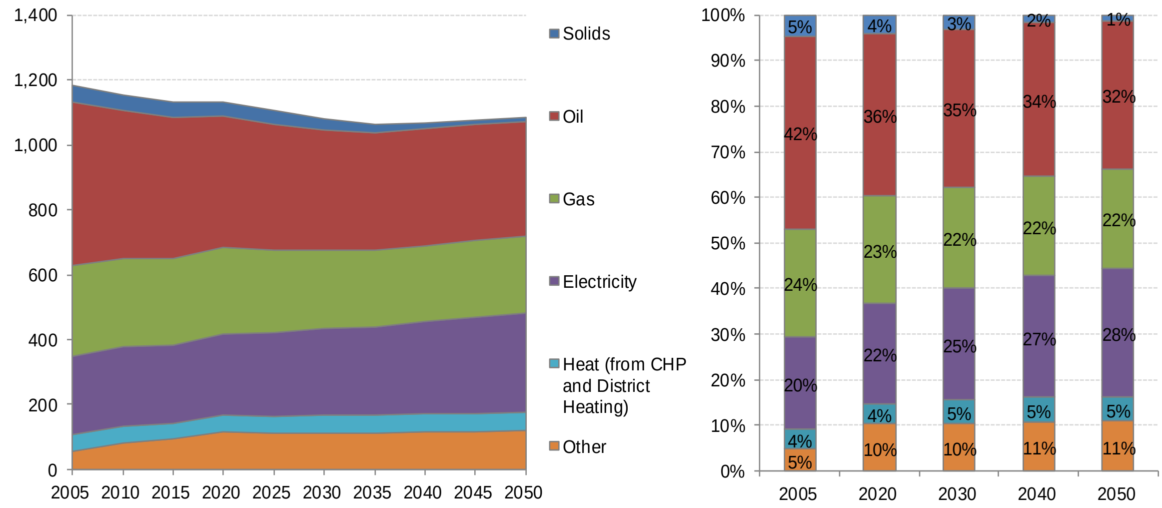
Figure 10: Evolution of final energy demand by sector (Mtoe – left, shares – right)



Source: PRIMES

With regard to the fuel mix in final energy demand (Figure 11), there is a gradual penetration of electricity (from 20% in total final energy use in 2005 to 28% in 2050). This is because of growing electricity demand as compared to other final energy use and to some electrification of heating (heat pumps) and to a limited extent of the transport sector.

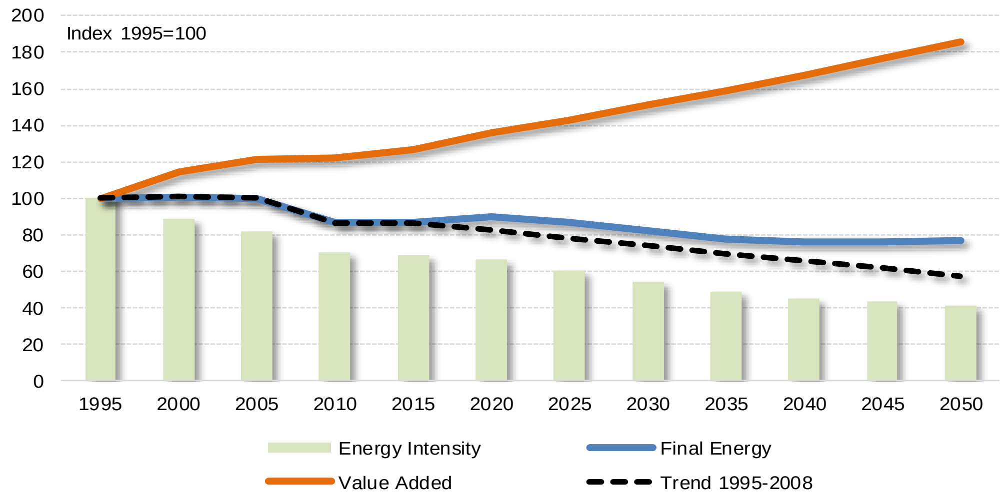
Figure 11: Evolution of final energy demand by fuel (Mtoe – left, shares – right)



Source: PRIMES

Energy intensity of the industrial sectors (Figure 12) remains approximately constant in the medium term, as additional energy demand is due to the increase in production activity. In the long term however energy demand decreases, even though activity in terms of value added progresses. This is due to the energy efficiency embedded in the new capital vintages which replace old equipment and structural changes towards higher value added and less energy-intensive production processes, such as in iron and steel or non-ferrous metals.

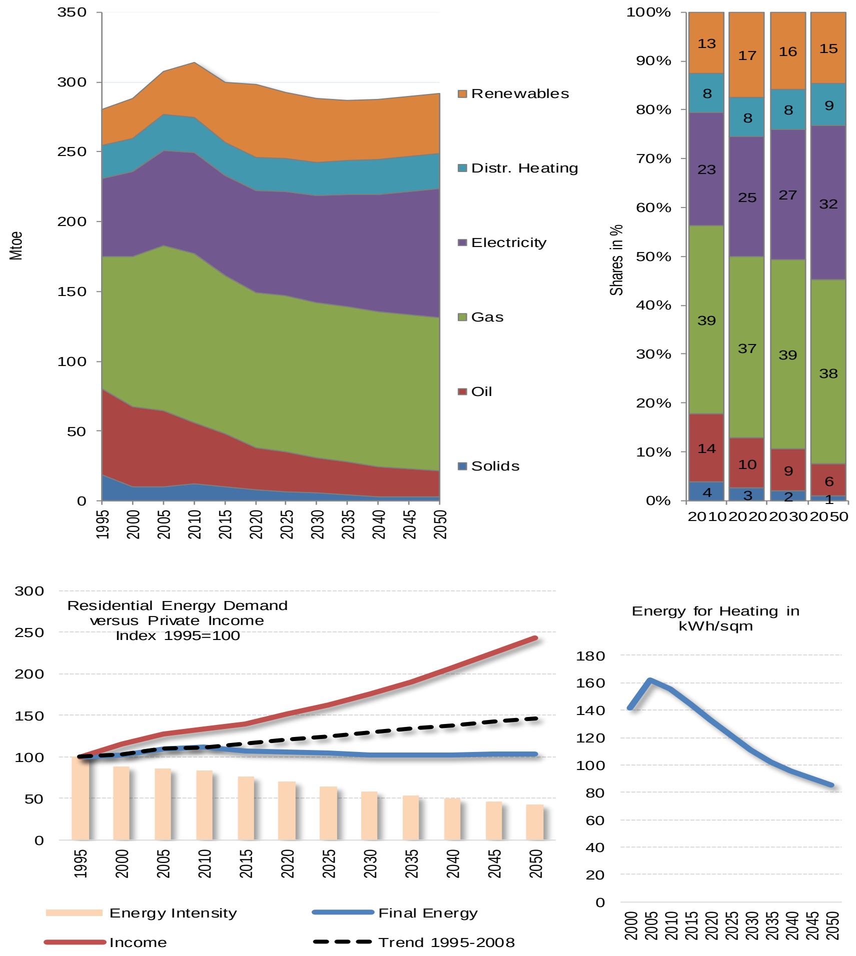
Figure 12: Industrial energy demand versus activity (value added)



Source: PRIMES

In the residential sector (Figure 13), energy demand remains below 2015 levels throughout the projection period. Energy demand decouples from income growth more than would be suggested by a simple extrapolation of past trends as the efficiency policies drive energy intensity improvements faster in the medium term; in the long term however the rate of improvements decreases due to the absence of additional policies.

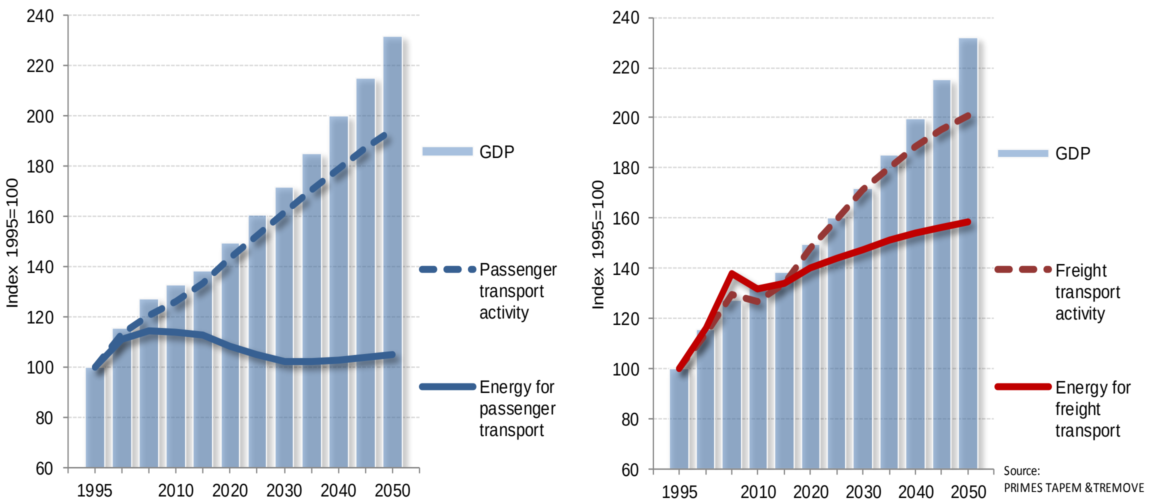
Figure 13: Final energy demand in the residential sector



Source: PRIMES

The activity of the transport sector shows a significant growth (Figure 14), with the highest increase in 2010 to 2030, driven by developments in economic activity. Historically, the growth of final energy demand in the transport sector has shown strong correlation with the evolution of transport activity. However, a decoupling between energy consumption and transport activity has been recorded in the past years. The decoupling between energy consumption and activity is projected to continue and even to intensify in the future.

Figure 14: Trends in transport activity and energy consumption



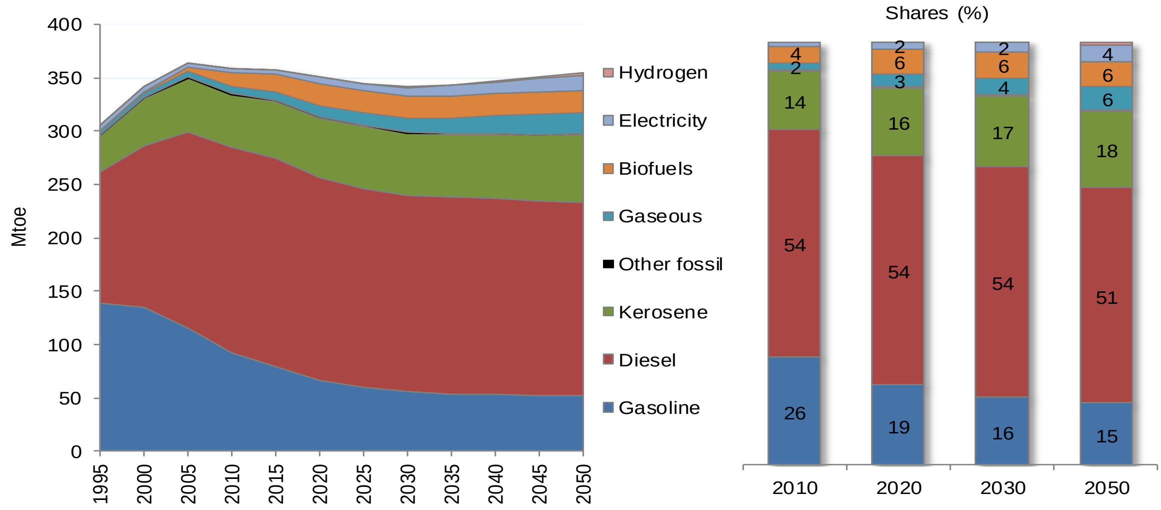
Source: PRIMES-TAPEM, PRIMES-TREMOVE and GEM-E3; For aviation, passenger transport activity includes domestic, international intra-EU and international extra-EU aviation.

Electricity use in transport is expected to increase steadily as a result of further electrification of rail and the uptake of alternative powertrains in road transport. However, its share is projected to remain limited in the Reference scenario, increasing from 1% currently to 2% in 2030 and 4% in 2050 (Figure 15). The uptake of hydrogen would be facilitated by the increased availability of refuelling infrastructure, but its use would remain low in lack of policies adopted beyond the end of 2014.

Liquefied natural gas becomes a candidate energy carrier for road freight and waterborne transport, especially in the medium to long term, driven by the implementation of the Directive on the deployment of alternative fuels infrastructure and the revised Trans-European Transport Network (TEN-T) guidelines which represent important drivers for the higher penetration of alternative fuels in the transport mix. However, the potential of gas demand developments in the transport sector do not fully materialise in the Reference scenario, suggesting that additional policy incentives would be needed to trigger further fuel switching.

Diesel is projected to maintain its share in total final energy demand in transport by 2030, slowly decreasing its share only during 2030-2050. Consumption of gasoline declines considerably until 2030, continuing the declining trend from 1995 and stabilizes from thereon to 2050. Consumption of jet fuels in aviation increases steadily by 2050 due to the strong growth in transport activity and despite improvements in energy efficiency.

Figure 15: Final energy demand in transport by fuel type



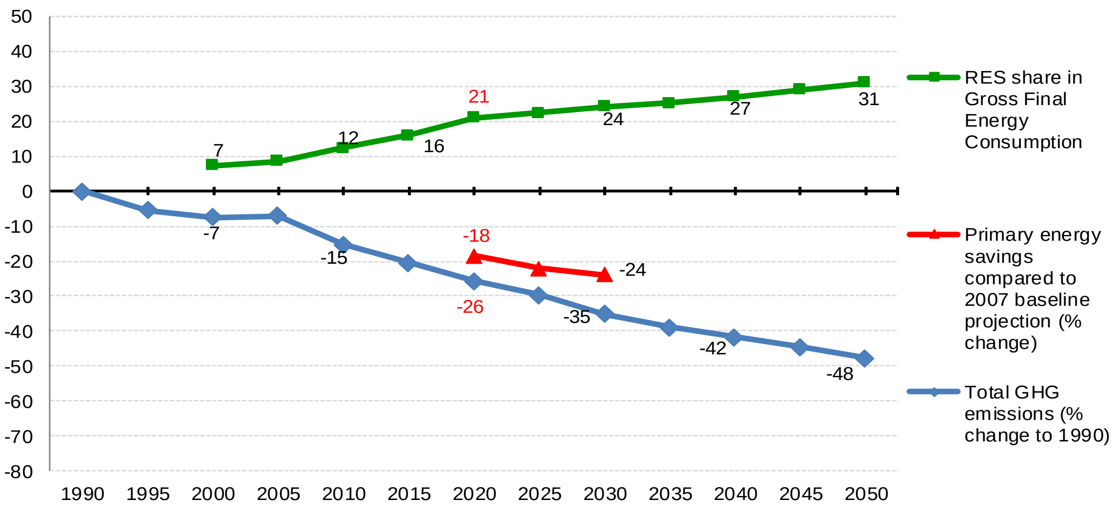
Source: PRIMES-TREMOVE; Biofuels include biomethane used in transport.

Oil products would still represent about 90% of the EU transport sector needs (including maritime bunker fuels) in 2030 and 86% in 2050, despite the renewables policies and the deployment of alternative fuels infrastructure which support some substitution effects towards liquid and gaseous biofuels, electricity, hydrogen and natural gas.

5. DECARBONISATION

REF2016 is set up to meet the binding energy and climate targets for 2020, the latter being achieved as a result of existing policies. However, it shows that current policies and market conditions will deliver neither our 2030 targets nor our long-term 2050 objective of 80 to 95% GHG emission reductions (Figure 16). In addition, as mentioned above, based on current market trends and adopted policies, the energy efficiency 2020 non-binding target is not met in REF2016, the scenario projecting a reduction in primary energy savings (relative to the 2007 baseline) of 18% in 2020, and, respectively, 24% in 2030. GHG emissions from sectors covered by the Effort Sharing Decision are projected to decrease by 16% in 2020 and by 24% in 2030 below 2005 levels, less than emissions in sectors covered by the EU Emission Trading System. The latter continue to decrease significantly after 2030 (Figure 6).

Figure 16: Projection of key policy indicators: GHG, RES, (EE)



Source: PRIMES, GAINS

5.1. Renewable Energy

In 2020, the RES share in gross final energy consumption reaches 21% in 2020, while in 2030, it increases slightly further, reaching 24%.

Renewable electricity is projected to increase (as a share of net power generation) from around 28% in 2015 to 36% in 2020, which implies an acceleration compared to observed trends today, in particular in a number of countries that are currently facing difficulties to meet their target. Further RES share increases are more limited until 2030, reaching 43%, as RES policies are phased out in REF2016 after 2020 and only the most competitive RES technologies are projected to emerge.

The RES share in heating and cooling (RES-H&C) increases from 17% in 2015 to 22% in 2020, reaching 25% in 2030. The use of RES in final demand for heating and cooling is the main driver of RES-H&C increase in the short term, but its contribution stagnates in the long term. In the long-term, RES in CHP and heat plants (e.g. district heating), as well as some deployment of heat pumps, drive further increase of the RES-H&C share. Energy efficiency, implying lower demand for heat in all sectors, is also an important driver in the medium and long term.

The RES share in transport (RES-T) reaches 11% in 2020. The development of biofuels is the main driver in the short term, but their contribution stagnate in the long term. The biofuel penetration is mainly driven by the legally binding target of 10% renewable energy in the transport sector. Projections also take into consideration specific Member State mandatory blending obligations and tax incentives, as well as the Indirect Land Use Change (ILUC) amendment of the Renewables and Fuel Quality Directives, and corresponding changes in RES-T target accounting rules. Higher share of RES in electricity, combined with the relative increase of electricity use in transport (albeit modest in share terms), is the main contributor to RES-T in the long term.

5.2. CO_2 emission reductions

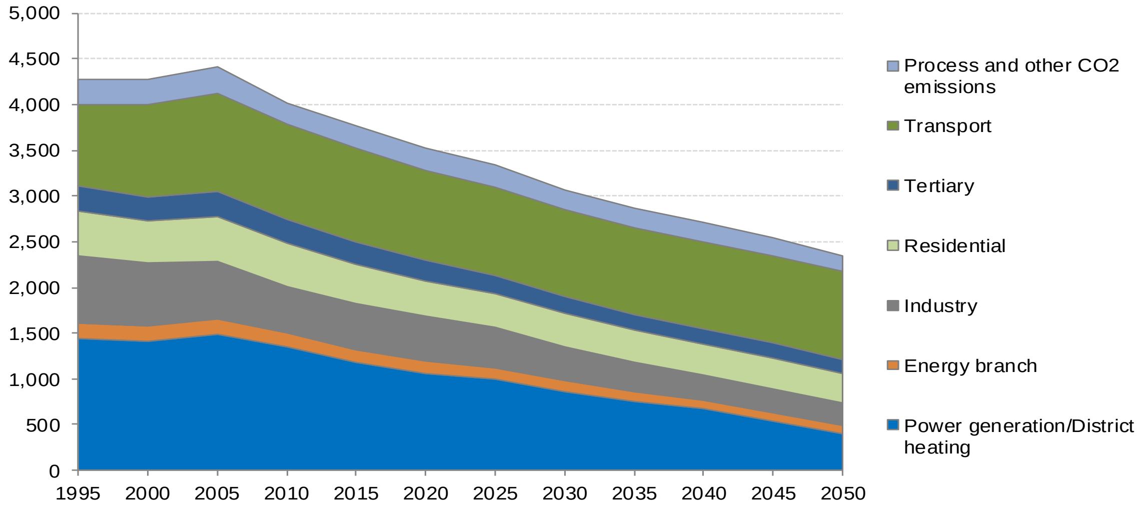
Total CO_2 emissions are projected to be 22% below 1990 levels by 2020. In 2030, CO_2 emissions reduce (relative to 1990 levels) by 32%. Most of these emissions are energy related, and this part also determines the overall trends. Non-energy related CO_2 emissions mainly relate to industrial processes, and remain rather stable. Land-use related CO_2 emissions are discussed below in the LULUCF section.

Emission reductions in the ETS sectors are larger than those in sectors covered by the Effort Sharing Decision (ESD) as current legislation implies a continuation of the reduction of the ETS cap with 1.74% per year over the projected period leading to a carbon price driving long term emission reduction. In the ESD sectors there are no further drivers beyond market forces (e.g. rising future fossil fuel prices) and the continued impact of adopted policies such as CO_2 standards for vehicles or energy performance standards for new building to further reduce energy and consequently emissions. Around two thirds of ESD sector emissions are CO_2 emissions, the rest are non-CO_2 emissions.

CO_2 emissions can be decomposed in the following components: GDP, Energy Intensity of GDP and Carbon Intensity of Energy. The Energy Intensity of GDP component declines due to structural changes in the economy and increasing energy efficiency in all sectors. The decrease of carbon intensity of energy supply becomes an increasingly significant component over the period. This is mainly due to Renewable Energy policies in the short term and the ETS in the medium to long term.

On a sectorial level, CO_2 emissions decrease in all sectors between 2010 and 2050. Figure 17 shows a steep decrease in power generation, whereas emissions in the field of transport decrease at much slower pace, and the transport sector becomes the largest source of CO_2 emissions after 2030. Non-energy and non-land use related CO_2 emissions (e.g. industrial processes) reduce only slowly throughout the projection period; however they only represent a small share of total CO_2 emissions.

Figure 17: Evolution of CO_2 emissions (Mt) by sector



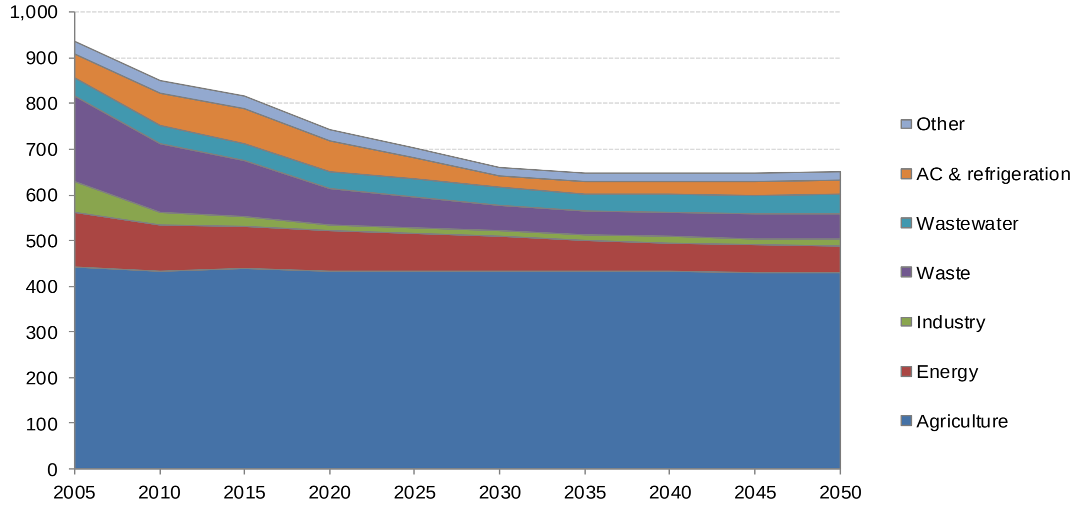
Source: PRIMES

5.3. Non-CO_2 GHG emission reductions

Non-CO_2 emissions (CH4, N2O and F-gases), accounted in 2013 for 18% of total EU GHG emissions (excluding LULUCF). They have decreased significantly (32%) between 1990 and 2013. They are expected to further decrease by 29% below 2005 levels in 2030 (-46% compared to 1990 levels), and to stagnate later on. CH_4 emissions – which have the largest share in this aggregate - are projected to decrease above average (33% due to declining trends in fossil fuel production, improvements in gas distribution and waste management) and N_2O emissions fall less than average (17%) until 2030, both remaining flat thereafter. F-gases would reduce by half between 2005 and 2030, largely driven by EU and Member State's policies (i.e. the 2014 F-gas Regulation and the Mobile Air Conditioning systems Directive). Except for a very minor fraction from some specific industries, non-CO_2 emissions fall under the ESD.

The non-CO_2 emission trends and their drivers vary by sector (Figure 18). Agriculture is responsible for about half of all non-CO_2 GHG emissions and is expected to increase its share in total non-CO_2 until 2030. While the agricultural non-CO_2 emissions have reduced by 22% between 1990 and 2013, they are projected to roughly stabilize at current levels as a result of different trends which compensate each other, such as decreasing herd sizes (both of dairy cows and of non-dairy cattle) but increasing milk yields. Slightly reduced use of mineral fertilizer through improved efficiency (2% less in 2030 than in 2005) leads to corresponding reductions in N_2O emissions from soils. Improved manure management (e.g. through anaerobic digestion) also delivers minor emission reductions. The Common Agricultural Policy influences, inter alia, livestock numbers/intensities and the Nitrogen Directive and the Water Framework Directive impact on the use of fertilizer.

Figure 18: Non-CO_2 GHG emissions (Mt CO_2 eq.)



Source: GAINS

Waste is currently the second most important sector emitting non-CO_2. There, a substantial reduction between 2005 and 2030 is expected (70%), strongly driven by environmental legislation, such as the Landfill directive and improvements in waste management as well as an update in inventory methodology of historic landfills that results in increased historic emissions and subsequent increased reductions of these emissions in the near to mid-term future. Also an increasing amount of CH_4 is recovered and utilised, thereby impacting on these trends towards lower emissions. After 2030, however, a moderate increase is projected, reflecting trends in economic development.

CH_4 and N_2O emissions from the energy sector (including transport) are expected to decrease by 36% from 2005 to 2030, and by 26% between 2030 and 2050. The main reductions come from less coal-mining and crude oil production in the EU, together with reduced emissions from power generation using fossil fuels. On the other hand, transport is expected to generate an increasing share of energy sector non-CO_2 emissions (N_2O from road transport being the most important contributor), growing from 12% in 2005 to 15% in 2030 and 20% in 2050 within the energy aggregate.

Emissions from air conditioning and refrigeration decrease by half from 2005 until 2030, also thanks to existing legislation (i.e. the new 2014 F-gas Regulation and the Mobile Air Conditioning systems Directive).

Most of the non-CO_2 emissions from industry – overall a minor non-CO_2 sector – are covered by the EU ETS (production of adipic and nitric acid, and of aluminium). The resulting incentives in combination with relatively cheap abatement options and existing national legislation cut emissions quite rapidly, to only a fifth in 2030 of those in 2005. For the period after 2030 slight increases are projected in line with economic trends.

Emissions from the wastewater sector and remaining other sectors are projected to increase moderately in line with economic development over the whole period covered.

5.4. LULUCF emissions and removals

The EU28 Land Use Land Use Change and Forestry (LULUCF) sector is at present a net carbon sink which has been sequestering annually on average more than 300 Mt CO_2 over the past decade according to the UNFCCC inventory data[6]. In REF2016, the LULUCF sink is expected to decline in the future to -288 Mt CO_2 eq in 2030 from -299 Mt CO_2 eq. in 2005 and decreases further after 2030. This decline is the result of changes in different land use activities of which changes in the forest sector are the most important. These changes are driven partly by the increase in timber demand (itself partially a result of the increase in bioenergy demand that is expected in order to reach the RES targets in 2020). Figure 19 shows the projection of the total EU28 LULUCF sink in REF2016 and the contribution from different land use categories.

At present, the carbon sink in managed forest land (-373 Mt CO_2 eq. in 2010 without applying any accounting rules[7]) is the main component of the LULUCF sink. The managed forest land sink is driven by the balance of forest harvest and forest increment rates (accumulation of carbon in forest biomass as a result of tree growth). Forest harvest is projected to increase over time from 516 million m^3 in 2005 to 565 million m^3 in 2030 due to growing demand for wood for material uses and energy production. Along with the aging of EU forest – which reduces the capacity of forest to sequester carbon – the forest increments are projected to decrease from 751 million m^3 in 2005 to 725 million m^3 in 2030. As a consequence, the rate of accumulation of carbon (i.e. the sink) in managed forest land declines by 32% until 2030. This is partially compensated by a continuation of increasing trend in carbon sink from afforestation and decreasing trend of emissions from deforestation which decline from 63 Mt CO_2 in 2005 to 20 Mt CO_2 eq. in 2030. Carbon sequestration from afforested land increases steadily to 99 Mt CO_2eq. by 2030, as new forests continue, albeit at slower rate, to be established. In addition, young forests that were established over the last 20 years get into a phase of high biomass production.

Activity in the agricultural sector (on cropland and grassland) has a smaller impact on the total LULUCF sink than the forest sector. Still, net carbon emissions from cropland are projected to decline by some 18% by 2030 compared to 2005 as soils converge towards soil carbon equilibrium over time. In addition, perennial crops (miscanthus, switchgrass and short rotation coppice) that typically sequester additional carbon in soil and biomass contribute to decreasing cropland emissions. By 2030, 0.9 Mha of perennial crops are expected to be cultivated. The grassland sink increases to around -19 Mt CO_2 eq. in 2030 as land continues to be converted to grassland e.g. through cropland abandonment while at the same time the total grassland area slightly declines over time due to afforestation and the expansion of settlements.

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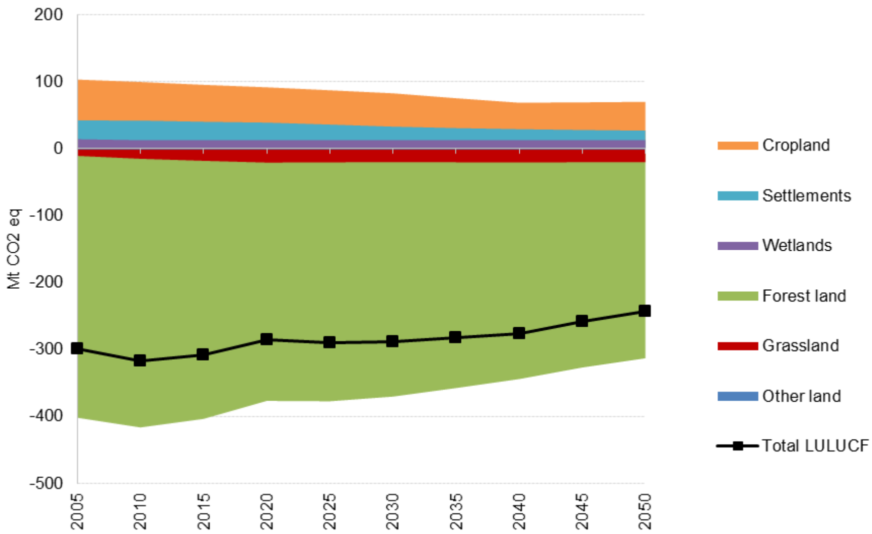
[6] See: http://unfccc.int

[7] The GHG accounting approach for LULUCF differs from other emission sectors. Notably, forest management is not accounted compared to historic emissions, but against a so called Forest Management Reference Level. This means that the accounted removals from the LULUCF sector are much smaller than the reported removals seen by the atmosphere.

Figure 19: EU28 emissions/removals in the LULUCF sector in Mt CO_2 eq. until 2050[8]



Source: GLOBIOM-G4M

8 Emissions from deforestation and harvested wood products are included in "Forest land" in contrast to UNFCCC inventories.

6. RESEARCH, INNOVATION AND COMPETITIVENESS

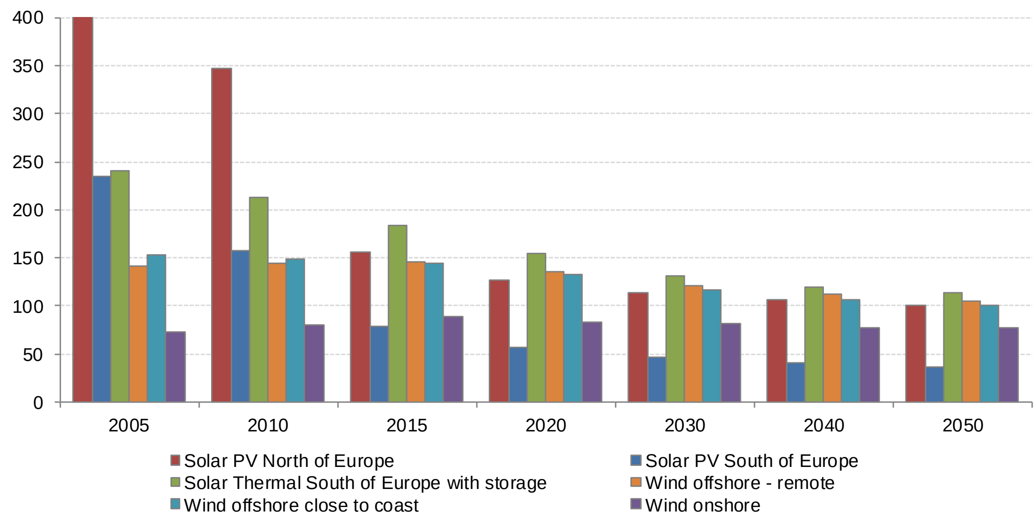
Although REF2016 does not deal explicitly with research and innovation, it does tackle directly the penetration of new technologies. The approach is in two steps. First, assumptions are made on techno-economic characteristics and technological learning curves based on latest scientific evidence[9]. Figure 20 presents an illustration of the RES power technologies assumptions used in REF2016. Second, the model endogenously selects the most economically viable technologies at each point in time, leading to further technological cost reduction as technologies are deployed at increasingly larger scales.

The development of solar photovoltaics (PVs) starts from lower costs than in the previous Reference Scenario and has a positive learning curve throughout the projection period. This translates into significant deployment of solar PVs in REF2016, especially in Southern Europe.

Although wind onshore costs are already competitive with many conventional technologies, the remaining potential for learning is estimated to be small, but costs can decrease due to the size of turbines and their height; very small scale wind is the only exception and still has high learning potential.

There remains large uncertainty about the costs for offshore wind and there have been cost increases due to previously unforeseen difficulties and logistics. Surveys have identified significant potential of cost decrease due to economies of scale and possibilities of improvement in logistics, but these cost decreases are likely to occur only towards 2030. As such, offshore wind developments in REF2016 are more conservative than in past exercises.

Figure 20: Illustrative levelized cost of electricity for selected RES technologies (expressed in €'2013/MWh-net)



Source: NTUA based on PRIMES

Compared to the previous Reference scenario, the costs of nuclear investment have increased and also the costs for nuclear refurbishments have been revised upwards. Although lifetime extensions of nuclear power plants remain economically viable in most cases, investments in new built plants are lower compared to previous projections.

The construction of power plants equipped with carbon capture and storage (CCS) technologies is developing at a very slow pace, and is dependent on public support (e.g.

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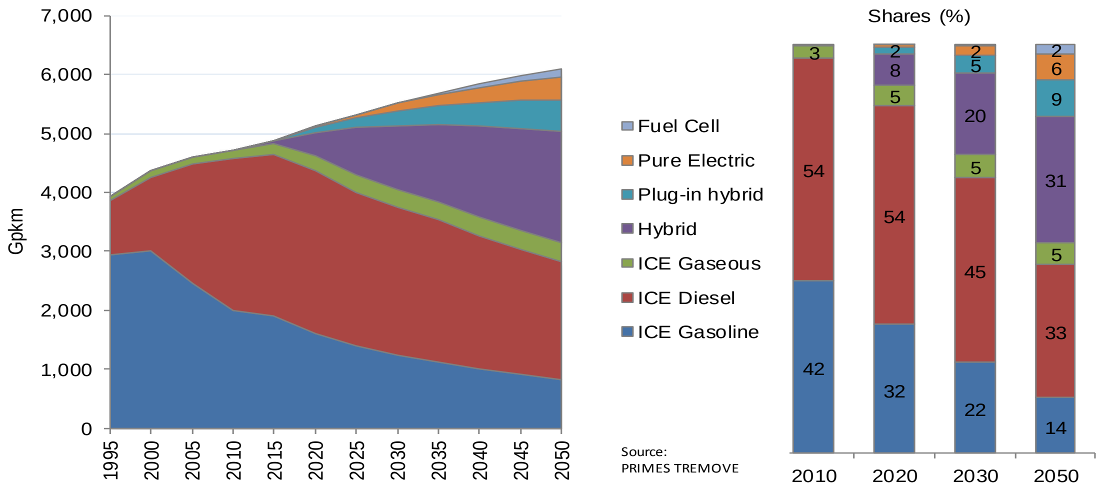
[9] See notably the European Commission's Joint Research Centre ETRI 2014 report, available at: https://setis.ec.europa.eu/publications/jrc-setis-reports/etri-2014

EEPR and NER300). Geological restrictions as well as current political restrictions on storage are also reflected. For these reasons, CCS costs are assumed higher than in previous Reference scenarios. Uptake of carbon capture and storage (CCS) in power and industry beyond supported demonstration plants remains very slow and occurs only towards the end of the projection period, driven by increasing ETS carbon prices.

On the demand side, demand for electric appliances continues to increase. However, there is an uncoupling between appliance stock and energy consumption due to the technological progress facilitated by ecodesign regulations.

Car manufacturers are expected to comply with the CO_2 standards by marketing vehicles equipped with hybrid system, which are becoming more appealing to the consumers thanks to lower costs. Electrically chargeable vehicles emerge around 2020 and are kick-started by existing EU and national policies as well as by incentive schemes aiming to boost their penetration. The share of activity of total electric vehicles in the total activity of light duty vehicles reaches 15% in 2050 (Figure 21). Fuel cells would add an additional 2% by 2050. Other energy forms such as liquefied petroleum gas (LPG) and natural gas maintain a rather limited share.

Figure 21: Evolution of activity of light duty vehicles by type and fuel[10]



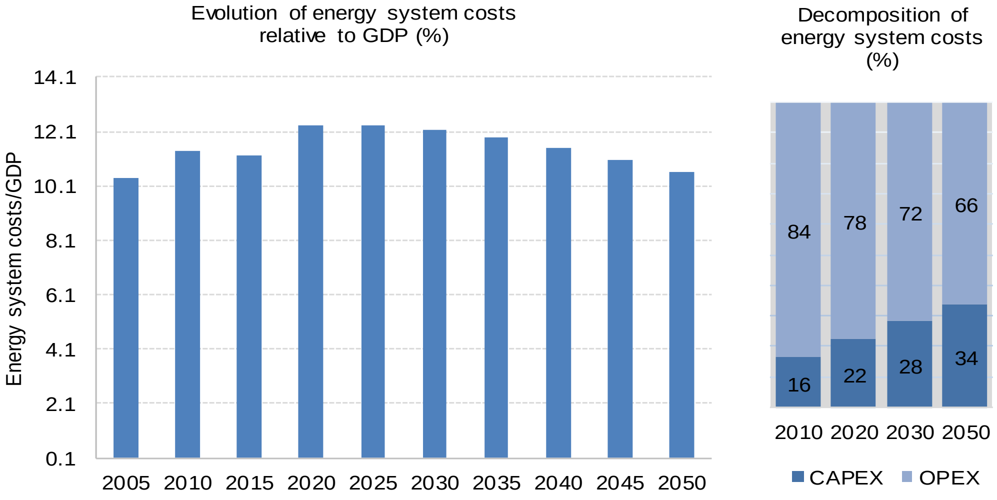
Source: PRIMES-TREMOVE

Energy system costs (Figure 22) increase up to 2020. Large investments are undertaken driven by current policies and measures (Figure 8). Overall, in 2020 energy system costs constitute 12.3% of the GDP, rising from 11.4% in 2010 and 11.2% in 2015, also driven by projected rising fossil fuel prices[11]. Despite further fossil fuel price increases, between 2020 and 2030 the share remains stable and decreases thereafter, as the system reaps benefits from the investments undertaken in the previous decade (notably via fuel savings). In this period, the share of energy system costs in GDP is gradually decreasing, reaching levels close to 2005 by 2050.

[10] Light duty vehicles include passenger cars and light commercial vehicles.

[11] Total system costs include total energy system costs, costs related to process-CO_2 abatement and non-CO_2 GHG abatement.

Figure 22: Projected evolution of energy system costs



Source: PRIMES; Energy system costs exclude ETS auction payments, given that they result in corresponding auction revenues.