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The revision of the trans-European energy network policy (TEN-E)

Final Report

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4.0	21/10/10	Sudhir Junankar	Final report – revised to address final comments made by Commission
3.0	25/08/10	Rachel Beaven	Final report – revised to address comments made by Commission.
2.0	12/08/10	Sudhir Junankar	Draft final report- Second version including some KEMA inputs, with Executive Summary, KEMA modelling results in Chapter 7 and their conclusions to be added in a later version
1.0	04/08/10	Hector Pollitt	Draft Final report – First version

Contents

Executive Summary

Introduction

- Energy security is a pressing concern within the European Union because of its influence on economic development and the well-being of citizens. Presently, the EU is dependent upon energy imports to meet its demand for energy, and if current trends and policies continue, this external dependency is likely to increase. There is an urgent need for the EU to develop its own internal energy infrastructure.
- The energy networks currently in place are dated and are not designed to cope with the energy challenges faced today, such as ensuring that:(i) the energy networks in place encourage the use of renewable and low carbon energy;(ii) as the EU continues to integrate, well-connected networks are in place; and (iii) investment in energy networks between the EU and external suppliers is sustained.
- The Strategic Energy Review[1] and the Green Paper *Towards a Secure, Sustainable and Competitive European Energy Network*[2]set about to address these energy infrastructure concerns. Recommendations included the completion of the Internal Energy Market, the incorporation of renewable energy sources into existing grid, and better connectionsbetween internal and external energy markets and natural resources.
- For these measures to be successfully implemented there is a need for the Trans-European Energy Network framework (TEN-E) to be revised, so that it is better suited to meet the energy policy objectives and energy challenges that the EU faces.
- The growing energy interdependency between Member States, the greater emphasis on achieving climate change goals and the increasing need to improve security of energy supply all present new challenges that TEN-E had not previously been designed to tackle.

Objective of the study

- The main objective of this study '*Revision of the Trans-European Energy Network Policy (TEN-E)'* was to support the European Commission's impact assessment of the policy review.
- The study assessed the benefits and drawbacks of different scenarios and policy options for TEN-E by estimating the investment needs and costs in the gas and electricity networks in the 2020 and 2030 time horizons, before analysing the economic, environmental and social impacts of a range of different investment scenarios.

Electricity investment needs

- The requirements for investment in electricity infrastructure were estimated using a modelling framework developed by KEMA and Imperial College London. Three scenarios were modelled, two based on the PRIMES reference scenario in 2020 and 2030 and a further 'High Renewable Energy Source' scenario (High RES) in 2030. The modelling results provide snapshots of electricity transmission network investment requirements, additional generation investments and associated operational costs aligned with the respective time horizon.

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[1] http://ec.europa/energy/strategies/2008/2008_11_ser2_en.htm

[2] http://eur-lex.europa.eu/LexUriServ.do?uri=CELEX:DKEY=483121:EN:NOT

- The modelling approach used a cost estimation methodology to provide a reasonable indication of the capital costs associated with expanding the transmission capacity to connectEU Member States.
- Using information from the PRIMES model and the ENTSO-E T*en Year Network Development Plan*[3]54 potential interconnections were identified between EU states for inclusion in the scenarios.
- Each interconnection was allocated one of three costs; standard, subsea or tough terrain, based on a general analysis of the terrain that would be encountered between the two regions.
- Using these identified interconnections and the costs assumptions, the total electricity infrastructure investment requirements for each of the modelled scenarios in 2020 and 2030 were calculated; the three scenarios evaluated reveal different infrastructure (network and generation) investment requirements as summarised in Table 1 (relative to the current position in 2010).

TABLE 1: SUMMARY OF ELECTRICITY INFRASTRUCTURE REQUIREMENTS

Scenario	Offshore wind power network infrastructure (€bn)	MemberState Interconnection Investment (€bn)	Additional generation investment for system reliability (€bn)	Annual operating cost (€bn)
PRIMES 2020	32.8	27.7	17.9	154.1
PRIMES 2030	50.4	28.1	41.7	160.1
High RES 2030	99.8	61.2	92.8	128.6

- Increasing deployment of intermittent renewable generation sources will increase investment requirements in the power sector, both in terms of network (transmission) and generation infrastructure. The results demonstrate that network and generation infrastructure requirements increase markedly as the capacity and geographic dispersion of RES is increased in order to facilitate resource sharing and maintain system reliability.

Gas investment needs

- The requirements for investment in gas infrastructure were determined by analysing the most recent studies and available documentation regarding gas infrastructure development projects, including investment in LNG terminals, natural gas storage and reverse flow projects.
- The findings for supply and demand for gas, and the difference between them, were then incorporated into the analysis of investment costs using cost assumptions drawn from the relevant literature.
- The analysis finds that additional capacity will be required to meet demand. It is assessed that planned pipelines will be sufficient to provide this capacity for demands in 2020, but that beyond 2020 new LNG terminals and developments in storage and reverse flow infrastructure will also be required.

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[3] https://www.entsoe.eu/index.php?id=232

- The total cost for new infrastructure in the gas sector is thus estimated at €25bn by 2030, of which the majority comprises new pipelines. In 2020, the estimated total investment for projects within the EU is between €3.4 bn and €5.6 bn.
- These estimates are additional to the estimated sum for external-EU projects in the gas sector and they do not include the expenses that have already been incurred for ongoing projects or the upgrades to address specifically the improvement of national grids.

Economic, environmental and social impacts

- The estimated investment costs for energy infrastructure were then used to develop three different types of scenarios,which were modelled using the E3ME model. These included scenarios specific to the electricity sector, scenarios specific to the gas sector, and finally combined scenarios.
- The projections published in *EU Energy Trends to 2030: Update 2009*[4]were used as the base case. Compared to this base case, the economic, environmental and social impacts of the different investment scenarios were then assessed.
- The results were considered on a country-by-country and sectoral basis. This was an important part of the analysis as many of the impacts were region and sector-specific, e.g. depending on the location of infrastructure and construction costs.
- The results show that the investment in energy infrastructure had a positive but small impact on GDP, principally as investment itself is a component of GDP. However, the investment also produced secondary ‘multiplier’ effects through other channels, such as increased consumer spending caused by increased employment.
- The countries that benefit the most were found to be those where the most investment is expected to take place. Similarly, the sectors that will see the greatest benefits are those that produce investment goods, including mechanical engineering and construction. However, all sectors will benefit to a certain extent from the additional investment.
- There was only a very small inflationary impact on prices, which was mainly due to capacity constraints in engineering and construction firms.
- The distributional effects were found to be negligible, so in this sense the investment policies assessed should be considered neitherprogressive nor regressive.
- There was a small increase in energy use and carbon emissions, mainly from the construction sector using additional materials.
- The scenarios also considered options in which 5% of the investment costs are met by public funding at a European level. This was compensated by a small increase in direct taxation rates so that the scenarios remained ‘revenue neutral’. This was found to have little impact on the macroeconomic outcomes.

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[4] (baseline 2009 and reference scenario 2009). A detailed description of these scenarios and their assumptions is available at http://ec.europa.eu/energy/studies/index_en.htm

1 Introduction and Project Overview

1.1 Overview

The present report has been prepared by Cambridge Econometrics under the existing COWI Multiple Framework Services Contract with DG TREN covering Impact Assessments and Evaluations (Ref. TREN/A2/143-2007 Lot 1 Energy) and in response to the Terms of Reference included under Work Order TREN/A2/143-2007/SI2.544824.

Readers should note that the report presents the views of the Consultant, which do not necessarily coincide with those of the Commission.

1.2 Structure of the project and this report

Overview of the project

The aims of the project were to:

- construct a forecast for energy demand
- compare this to expected supplies
- estimate the investment costs required for meeting excess demand
- evaluate the economic impacts of these costs

Throughout this report we consider both the electricity and gas supply industries.

It should be noted that we have considered the second of these points from two different perspectives for the electricity sector. The first, described in detail in Appendix V, is a literature review of the information that was available at the time. The second is a model-based approach, for which the results are presented in Chapter 3.

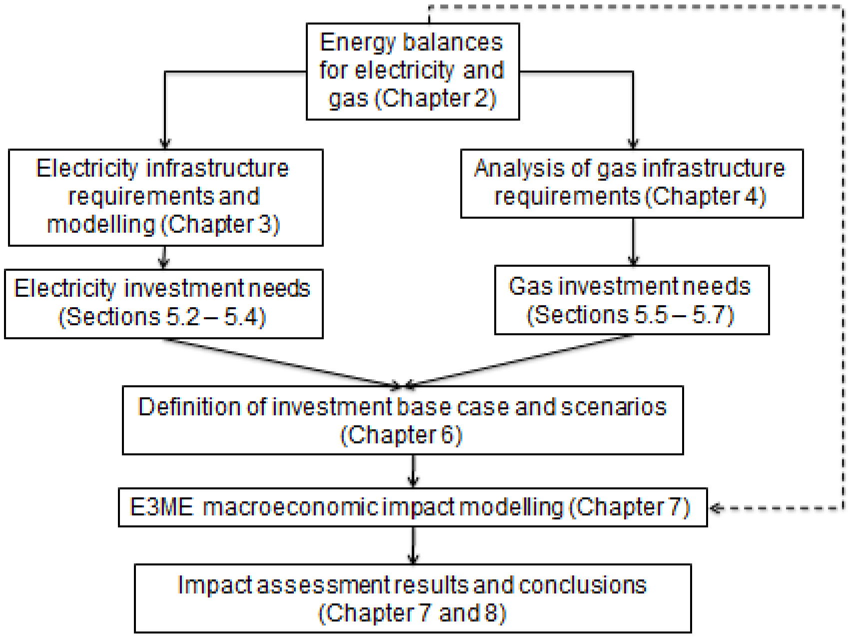
Structure of thisreport

This report presents the final outputs from the project and the structure of the following chapters broadly matches against the project tasks.Chapter 2 briefly introduces the projections of energy demand that were used in the study and Chapters 3-5 discuss projections of supply and infrastructure requirements, both in terms of capacity and in terms of financial cost.

The scenarios that were modelled are presented in Chapter 6.The macroeconomic results from the E3ME modelling exercise are presented in Chapter 7 with some conclusions given in Chapter 8.

Figure 1.1 shows how the different tasks, and the chapters of this report, fit together.

FIGURE 1.1: OVERVIEW OF TASKS



The appendices to this report are presented in a separate document and are as follows:

- Appendix I identifies new power transmission projects based on information from UTCE, Nordel, CESI and BALTSO;
- Appendix II provides details of the size of power transmission equipment based on information from UTCE, Nordel, CESI and BALTSO;
- Appendix III details the results from the TradeWind study;
- Appendix IV lists the TEN-E projects that are eligible for EC grants under Decision No 1364/2006/EC;
- Appendix V provides a literature review of electricity infrastructure requirements;
- Appendix VI provides background data and the calculations used in Appendix V;
- Appendix VII provides background data to Chapter 4;
- Appendix VIII provides a version of the tables in Chapter 4 expressed in alternative units (Mtoe);
- Appendix IX provides detailed descriptions of the E3ME and KEMA models.

2 The Base Case Demand Projections

2.1 Overview of the base case

Our projections of energy demands are calibrated to match the reference case from *EU Energy Trends to 2030: Update 2009*[5], which are produced using the PRIMES model. This means that the analysis was carried out on a consistent basis with other studies being undertaken by DG Energy and in other parts of the Commission.

In the reference scenario, the 2020 targets for GHG emissions and renewable power generation are assumed to be met.

The projected energy balances, derived from the PRIMES reference scenario, feed directly into the analysis of infrastructure requirements, required for the analysis in the following chapters and in the KEMA model. These projections also form the base case for use in the E3ME model.

2.2 The role of the base case

The intermediate report for the project described why it is important to use a consistent base case and gives a technical description of the calibration process that is used in the E3ME model and how the data were expanded to match the model's classifications; this is briefly described again in Section 6.2.However, in this project the main role of the base case is in providing the energy demands that must be met by the available infrastructure (supply). It is therefore referenced extensively throughout the following chapters.

2.3 PRIMES demand projections

Table 2.1 provides a summary of the demand projections produced by the PRIMES model in both the baseline and the reference scenario.

TABLE 2.1: PRIMES EU27AGGREGATE ENERGY DEMAND PROJECTIONS (Mtoe)

		PRIMES Baseline		**PRIMES Reference scenario**	
	2005	**2020**	**2030**	**2020**	**2030**
Natural Gas	283.5	279.4	264.9	259.3	233.6
Electricity	237.5	276.7	302.5	270.8	298.0

Source(s): EU Energy Trends to 2030: Update 2009.

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[5] Baseline 2009 and reference scenario 2009. A detailed description of these scenarios and their assumptions is available at http://ec.europa.eu/energy/studies/index_en.htm .

3 Modelling of Electricity Infrastructure Requirements

3.1 Summary of literaturereviewresults

A literature review based on information provided by TSOs, institutional organisations and the European Commission, amongothers, wasconducted to provide an initial evaluation of electricity infrastructure requirements[6].

Based on the lengths of the planned projects identified by the literature review, plus the demand projections from the PRIMES model, the excess transmission needscouldbedetermined.

This approach suggests that in 2020 4,812MW of interconnection capacity will be required beyond developments that are already planned.In 2030 this figure is 8,245MW.Table 3.1 breaks the figures down by country.

TABLE 3.1: SUMMARY OF EXCESS TRANSMISSION CAPACITIES (MW)

Country	To be covered by 2020	To be covered by 2030
Austria	45	13
Belgium	231	219
Bulgaria	565	524
Czech Rep	390	1,742
France	496	
Germany	807	764
Poland	31	547
Romania	996	1,415
Slovenia	22	
Spain	155	308
Sweden		94
Other	1,074	2,618
Total	4,812	8,245

Source(s): European Commission, author's own calculations.

A more detailed discussion of the findings of the literature review can be found in Appendix V.

3.2 Modelling of electricity infrastructure requirements

The KEMA/ICL modelling framework contains a number of modules that together provide a coherent methodology for estimating the additional generation and network investment requirements and the power system operation costs of alternative generation mix scenarios. This framework was used to provide an alternative view on electricity infrastructure requirements, also taking into account the most recent data

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[6] It should be noted that the literature review was carried out prior to the publication of the ENSO-E *Ten Year Network Development Plan* published in summer 2010.

provided by ENTSO-E's *Ten Year Network Development Plan*(TYNDP). It divides the investment requirements into two parts:

- an investment estimate for the interconnection requirements between Member States utilising the applied power systems analysis framework[7](APS model) to evaluate cost-optimal regional interconnection and generation capacity requirements for system security purposes, and the annual operating costs of the system;
- an investment estimation for the cost of integration of offshore wind capacity based on a separate estimation tool.

The investment model divides the EU27 countries plus Norway and Switzerland into 29 regions.Today's congestion within the member state regions associated with the existing networks is not considered and is assumed to be addressed in the ENTSO-E TYNDP. The model trades off the various investment elements and optimises based upon input cost assumptions.

For the transmission investment element, three composite costs are created to capture a range of network expansion costs applicable across Member States.These costs have been derived to recognise the different technical solutions required for future transmission interconnection, such as overhead lines, cables, HVAC & HVDC technologies.However, this approach does not provide specific costs for any particular circuits to form the indicated transmission capacity.

Each Member State region has been allocated a notional 'centre of gravity', which functions as the point from and to which transmission capacity will be required. The scope of the transmission system analysis is focused on incremental capacity requirements between the regions for each future scenario relative to the current 2010 base case, but respecting the anticipated 2020 transmission capacities contained within the ENTSO-E TYNDP, ie all investments in the ENTSO-E TYNDP are assumed to happen in all scenarios.

The model does not assess the investment requirements for connections due to growing demand or investment in the distribution network.

The offshore wind farm and solar CSP transmission integration costs are derived separately from the interconnection between Member States.Each offshore wind park is assumed to require increased network capacity in order that the associated electrical energy can be transmitted to the centre of gravity of the MemberState, within which the wind farm is located.

The network expansion cost factors used to calculate future transmission investments have been selected to represent the average cost of secure transmission capacity expansion and also include an allowance for additional reinforcements within each MemberState for the connection of new generators. Further explanation of the assumptions regarding transmission expansion factors are provided below.

More detailed transmission studies, with ENTSO-E coordination, will be needed in the future to support more granular cost estimation and decision-making..

Scenarios

Three scenarios were modelled, two based on the PRIMES reference scenario in 2020 and 2030 and a further 'High Renewable Energy Source' scenario (High RES) in 2030.The modelling results provide snapshots of electricity transmission network

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[7] Developed by Imperial College London.

investment requirements, additional generation investments and associated operational costs aligned with the respective time horizon.

3.3 Common assumptions

Electricity system architecture For each scenario, the European electricity system is modelled as a 29 node system with 54 defined interconnection possibilities between these nodes.

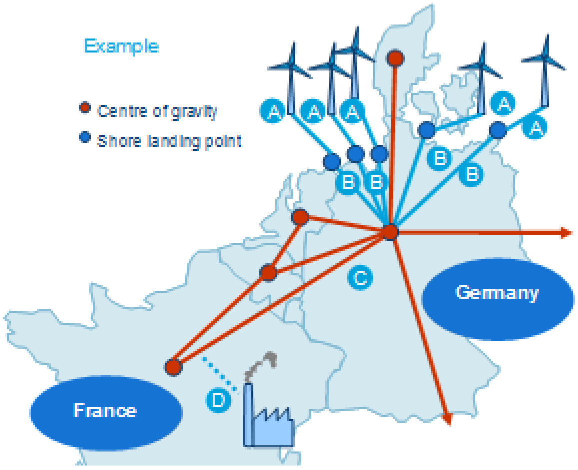
Consumption The system consumption and peak demand characteristics are common in the two 2030 scenarios and greater than the overall electrical energy requirement assumed in the 2020 scenario.The consumption data for all scenarios is aligned with PRIMES reference scenario consumption forecasts including the net import/export position.These annual consumption values per country are translated into daily profiles.These are created by adapting the most recent information available on the hourly country demand over the day, week, weekend and seasonally in order to create instantaneous demand profiles consistent with future annual electricity consumption.These profiles are subsequently adjusted to reflect the potential for fuel switching with respect to building heat requirements (from gas to electricity), and transportation (from oil to electricity).These give rise to an overall increase in peak demand of 5% for 2020 and 10% for 2030 scenarios.

Generator and technical characteristics A range of dynamic technical constraints and cost characteristics of generating plant were considered (including minimum stable generation levels, ramp rates, minimum up/down times, start up, no load costs) together with energy storage reservoir capacities, efficiency losses and demand response that may be available. Assumptions regarding the technical characteristics of generation plant are consistent with the assumptions adopted for the European Climate Foundation Roadmap2050 project, which are based on current industry standards and learning rates as tested extensively with key industry stakeholders.

Transmission expansion factor assumptions The modelling approach relies on a cost estimation methodology.It seeks to provide a reasonable indication of the capital costs associated with expanding the transmission capacity between regions to maintain a power system with security characteristics similar to those experienced today.The costs are estimated based on an assumption that these will deliver a secure transmission network satisfying the ‘N-1’ criterion, ie providing sufficient network redundancy such that a single fault would not cause transfer capacity to be reduced.

Figure 3.1: Transmission Investment

Transmission investment has four elements



A Transmission of off-shore wind parks to shore

B Transmission of shore landing point to centre of gravity

A & B, not part of optimisation model
Estimated using average cost and length and number of links based on installed wind farm capacity

C Transmission between centres of gravity of regions [1]

Focus of the optimisation model.
Reinforcement costs assumed by region based on one of three possible cost mixes - standard, subsea or tough terrain

D Transmission and distribution within region to end user
Not in scope

1 This assumes a firm capacity capability from centre of gravity to centre of gravity that would allow for the dispersion of power along the way implicitly covering intra-regional reinforcements

SOURCE: KEMA

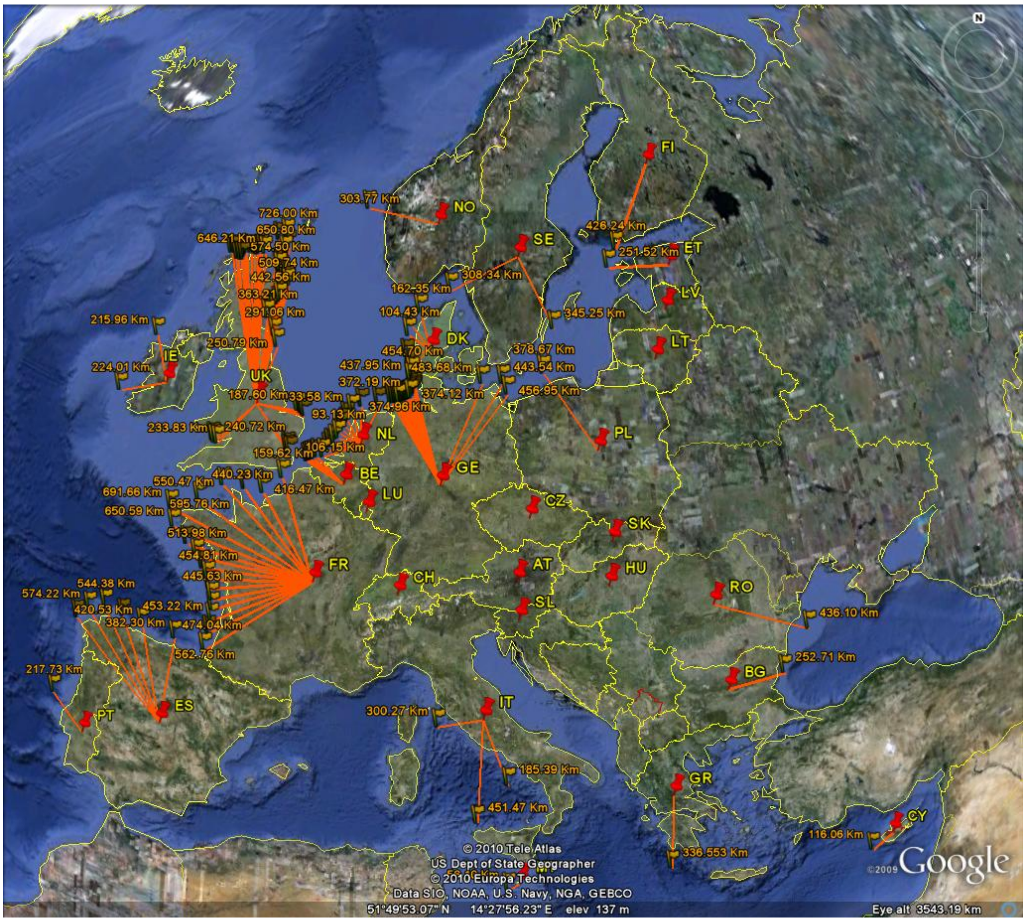
The transmission costs estimations include several elements.The costs of subsea cables for the offshore wind farms (A in Figure 3.1) are estimated based on a typical distance from the shore and a single unit cost of €4m per GWkm.

Network investments associated with the distribution of increased demand (Part D) is excluded from the transmission modelling.This is because the increased demand to be met in all of the scenarios is the same and therefore it is assumed that the costs to meet these demand increases will appear in each case.

The transmission network investment cost modelling undertaken addresses elements B and C in Figure 3.1, however, the methodology adopted to estimate the capacity and costs is different for each element.

Part B transmission capacity is calculated by evenly distributing the total assumed offshore wind farm capacity along the available coastline of the region. This requires the total offshore wind capacity to be divided into wind parks.These are limited to a maximum of 1.5GW capacity, reflecting a conservative assumption for a typical circuit capacity.From each of the landing points distributed evenly along the regional shoreline, it is assumed that additional capacity will berequired to transmit the wind farm output to the centre of gravity, before it can be transmitted more widely (see Figure 3.2).This methodology has also been adopted to reflect the likely concentration of solar CSP in southern Spain where it has been assumed that 75% of the solar CSP parks are connected to the south of the centre of gravity.The ‘Standard’ cost expansion factors (see Figure 3.3) have been used for these investments.

Figure 3.2: Representation of the Investment Requirements for Integration of the Offshore Wind Parks for the High RES 2030 Scenario



The detailed modelling focuses on the Part C investments, in Figure 3.1. The costs of the Part C investments are integrated within the wider APS framework. The modelling framework uses the composite cost assumptions shown in Figure 3.3 to undertake a cost optimisation.Each composite cost assumes a balanced approach to technology selection based on experience of network developments. Each international interconnector is allocated one of the three composite costs (standard, subsea or tough terrain) based on a general analysis of the terrain that would be encountered between the centres of gravity.The composite cost assumption allocated to each interconnector is shown in Table 3.2.

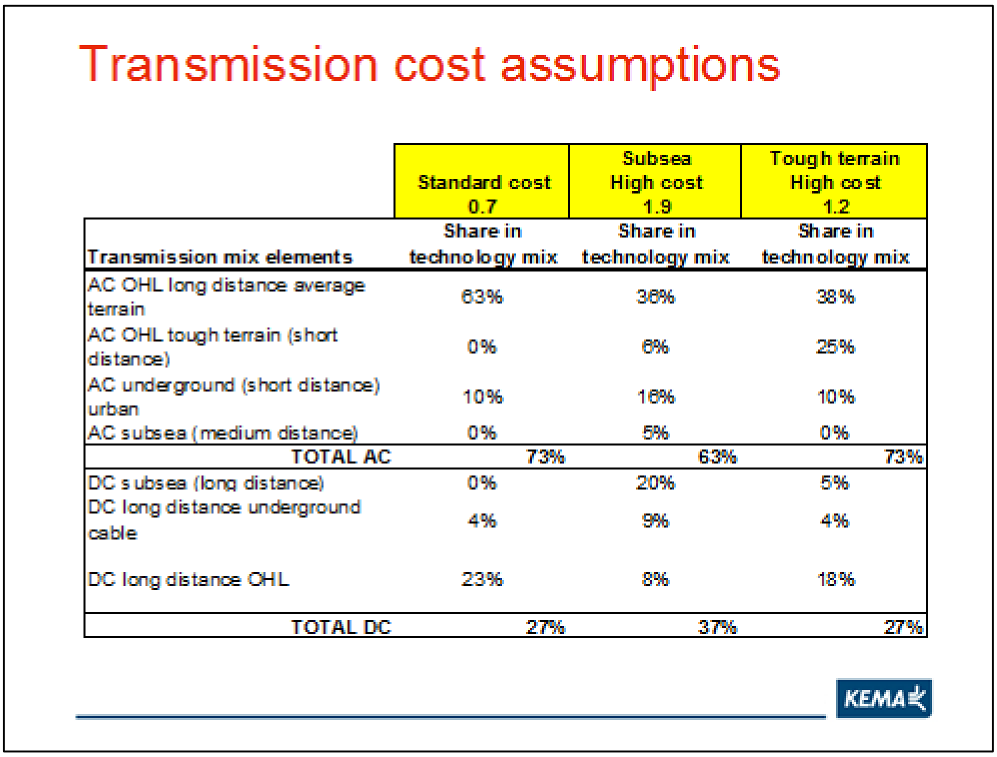
TABLE 3.2: CATEGORISATION OF EACH INTERCONNECTION

Link No	Countries Interconnected	Cost type
1	GB - Ireland	Subsea
2	GB - France	Subsea
3	GB - Netherlands	Subsea
4	GB - Belgium	Subsea
5	GB - Norway	Subsea
6	Norway - Netherlands	Subsea
7	Norway - Germany	Subsea
8	Norway - Denmark	Subsea
9	Norway - Sweden	Tough terrain
10	Sweden - Denmark	Subsea
11	Sweden - Finland	Subsea
12	Sweden - Lithuania	Subsea
13	Sweden - Poland	Subsea
14	Sweden - Germany	Subsea
15	Finland - Estonia	Subsea
16	Estonia - Latvia	Standard cost
17	Lithuania - Latvia	Standard cost
18	Poland -Lithuania	Standard cost
19	Poland - Czech Republic	Standard cost
20	Poland - Slovakia	Tough terrain
21	Poland - Germany	Standard cost
22	Germany - Denmark	Standard cost
23	Germany - Netherlands	Standard cost
24	Germany - Belgium	Standard cost
25	Germany - Luxembourg	Tough terrain
26	Germany - Switzerland	Tough terrain
27	Germany - Austria	Tough terrain
28	Germany - Czech Republic	Standard cost
29	Germany - France	Tough terrain
30	France - Spain	Tough terrain
31	France - Italy	Subsea
32	France - Switzerland	Tough terrain
33	France - Belgium	Standard cost
34	Belgium - Netherlands	Average cost
35	Belgium - Luxembourg	Average cost
36	Netherlands - Denmark	Subsea
37	Spain - Portugal	Tough terrain
38	Italy - Switzerland	Tough terrain
39	Italy - Austria	Tough terrain
40	Italy - Slovenia	Tough terrain
41	Italy - Greece	Subsea

TABLE 3.2: CATEGORISATION OF EACH INTERCONNECTION

Link No	Countries Interconnected	Cost type
42	Italy - Malta	Subsea
43	Czech Republic - Slovakia	Tough terrain
44	Austria - Switzerland	Tough terrain
45	Austria - Slovenia	Tough terrain
46	Austria - Czech Republic	Tough terrain
47	Austria -Slovakia	Tough terrain
48	Austria -Hungary	Tough terrain
49	Slovenia - Hungary	Tough terrain
50	Hungary - Slovakia	Tough terrain
51	Hungary - Romania	Tough terrain
52	Romania -Bulgaria	Tough terrain
53	Bulgaria - Greece	Tough terrain
54	Greece - Cyprus	Subsea

Figure 3.3: Transmission Cost Assumptions



Transmission cost assumptions

	Standard cost 0.7	Subsea High cost 1.9	Tough terrain High cost 1.2
Transmission mix elements	Share in technology mix	Share in technology mix	Share in technology mix
AC OHL long distance average terrain	63%	36%	38%
AC OHL tough terrain (short distance)	0%	6%	25%
AC underground (short distance) urban	10%	16%	10%
AC subsea (medium distance)	0%	5%	0%
TOTAL AC	73%	63%	73%
DC subsea (long distance)	0%	20%	5%
DC long distance underground cable	4%	9%	4%
DC long distance OHL	23%	8%	18%
TOTAL DC	27%	37%	27%

KEMA

Generation expansion cost assumptions

The APS model includes a reliability assessment, which determines whether additional generation capacity is required beyond that provided within the scenario to achieve an overall energy balance with the requisite level of system security.Additional generation capacity is added where the APS model finds that the level of generation security falls below the historic loss of load expectation benchmark.This additional generation is assumed to be peaking plant and would operate infrequently for short periods.Open Cycle Gas Turbine technology has been used as the default generation source for any such capacity shortfalls, added at a cost of €0.35 million per MW of capacity.

3.4 PRIMES scenario

Generation

The European Commission provided KEMA/ICL with the latest issue (Ver.4 - April 2010) of PRIMES reference scenario for the EU27 Member States.The Net Installed Power Capacity (in MWe) and the Gross Electricity generation by fuel type (in GWh) were used as the basic input data to build the scenarios for 2020 and 2030. A number of adjustments were applied to the original data in order to harmonise it with KEMA/ICL model input format. Data for Norway (NO) and Switzerland (CH) was not available in the latest PRIMES data (Ver.4 – April 2010) and therefore, Ver.3 (2007, pre-crisis projections) formed the basis for these countries.This previous data was adjusted for the economic downturn with the electricity consumption of NO and CH decreased using the trends seen in neighbouring countries. Production from renewable electricity generation sources in the PRIMES 2020 & PRIMES 2030 reference scenario equate to 33% and 36% respectively.

Fuel costs

There was no modelling of the impact of fossil fuel prices in the two PRIMES reference scenarios, because these simulations were primarily focussed on maintaining the pre-defined output characteristics for each generation source, ie fuel cost optimisation was a secondary factor in these simulations. For the PRIMES scenarios, the models were constrained to retain close alignment with MemberState capacity/production projections.

Base case international interconnection capacity

For both PRIMES scenarios, 54 potential links were identified between EU Member States for inclusion in the model.In PRIMES 2020 scenario, the actual 2010 capacity values were used as input in the model, whereas in PRIMES 2030 the future interconnection capacities from the ENTSO-E TYNDP were incorporated[8].

3.5 High RES 2030 scenario

The High RES scenario was derived from a scenario developed for the European Climate Foundation’s Roadmap 2050 project.The ECF 2050 80% RES scenario defined a scenario where 80% of the electricity production in the EU27 plus Norway and Switzerland (EU27+2) was to come from renewable energy sources.This defined a volume of generation capacity from renewable sources (wind, solar, hydro, biomass etc) with the remaining 20% of production produced by coal (5%), gas (5%) and nuclear (10%).From this assumed generation mix, the ECF Roadmap2050 ‘Pathway’ was projected back in time to the present day to provide interim generation mixes for the EU27+2. For the High RES scenario, KEMA/ICL adopted the generation mix from the 2050 ECF 80% RES Pathway, with capacities cast back to 2030.

As the ECF Roadmap2050 project did not provide a Member State level division of the generation capacity, KEMA developed a process to allocate the total EU27+2 generation capacity between the 29 individual countries in terms of installed capacity by technology type. The methodology for this is described below.

The starting point for the development of this scenario was the ‘backcast’ 2030 regional generation capacities as derived from in the ECF 80% RES Pathway.

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[8] All investments were included from the ENTSOE TYNDP except for two projects that are planned for beyond 2020. The projects are to develop new lines between Italy and Austria, and Austria and Slovakia. These were not included in the 2020 baseline network architecture.

TABLE 3.3: GENERATION MIX BACKCAST FOR 2030

Technology type	EU29 installed capacity in 2030 (GW)
Nuclear energy	94
Hydro (pumping excluded)	207
Wind on-shore	143
Wind off-shore	190
Solar PV	341
Solar CSP (only for Spain)	20
Coal (CCS+Conventional)	50
Oil (included in Gas)	0
Natural gas (CCS+Conventional)	140
Biomass-waste fired	69
Geothermal heat	4
Other Renewables	0
Total (Excluding back-up)	1,258
Additional back-up	135
Total	1,393

Source(s): European Climate Foundation’s Roadmap 2050 project.

The next step allocated the total EU installed capacity per technology to each of the 29 countries. The allocation of capacity was done by taking the ratio of each individual country production of the particular generation type, and the total EU production of that generation type.For example, if the Netherlands has 12% of total EU wind production (GWh) in 2030 according to PRIMES, it will receive 12% of the wind capacity (GW) in the High RES 2030 scenario. The additional back up capacity that was calculated as part of the ECF 80% RES scenario in the Roadmap 2050 project was not taken into account. It was recalculated as a result of this modelling exercise.

Following the allocation of capacity, the production for each country and technology was then determined using the projected load factors derived from the PRIMES 2030 data for each generation type.This process does not ensure that production meets projected consumption.An overall energy deficit was found because the ECF Roadmap 2050 scenario had an overall lower level of consumption than the High RES scenario.

To ensure an energy balance a further step was taken to ensure the total EU27+2 generation (in TWh) of the High RES 2030 scenario matched the consumption (including net export/import) projected in PRIMES 2030.

The net deficit of generation was eliminated by adding additional installed capacity into the system.Generation capacity was incrementally added equally to coal and natural gas technologies, until the annual energy balance was achieved. In total, 96.5 GW of additional capacity were added.

Hydro Generation

The initial capacity mix in the High RES 2030 scenario did not make any provision for the division between the various categories of hydro generation. The same ratios were applied from the PRIMES 2030 to the High RES scenario.

Fossil Fuel Prices

In the 2030 High RES scenario, modelling constraints were relaxed in order that fuel/generation cost variations across Member States could be economically optimised with increased potential for resource sharing.

For the High RES scenario, fossil fuel prices were modelled based on forecasted International Prices provided with the PRIMES dataset. PRIMES assumesa single international fuel price for each fuel, coal, oil and natural gas, and these prices are uniform across all Member States (in € '08 per boe). The APS model uses a fuel cost input that represents the cost of fuel per MWh of electrical output.This aggregates variations in plant efficiency, fuel consumption and local fossil fuel prices into a single input.For the High RES scenario these inputs by country were derived from PRIMES using the following method:

- total fuel input costs were determined (in €) per Member State based on the total volume of fuel input in thermal power generation (by fuel type) and the international fossil fuel prices for that fuel type (for oil, coal and natural gas) from the PRIMES model for 2030;
- individual country fossil input fuel prices for generation in €/MWh were calculated by dividing the total fuel input cost by the corresponding gross electricity generation (in MWh) by fuel type for each of the 29 countries;
- this created a varying input cost per MWh of electrical output between countries, that is a proxy for the aggregated variations including local delivered fuel costs and plant efficiencies.

Interconnection Capacity

For the High RES scenario, we identified 54 potential links, between EU members, for inclusion in the model and the actual 2010 capacity values were used as inputs to the model.The High RES pathway is assumed to be aligned with the PRIMES reference scenario up to 2020 and then diverges to achieve a significantly higher percentage production from renewable sources (49% - from a possible 51% with 1.6% being curtailed) of electricity by 2030 and assumes delivery of the ENTSO-E TYNDP investments.

Investment Needs

The KEMA/ICL modelling work described above assesses alternative future investment requirements for the electricity sector; the findings are reported in Chapter 5.

4 Analysis of Gas Infrastructure Requirements

4.1 Introduction

Specific aspects of the gas market

In contrast to the electricity sector, in which cross-border transit capacities are only part of the capacity at national level, one of the most salient features of the natural gas (NG) sector is the importance of transit flows in many countries vis-à-vis the local consumption.

Another specific aspect is the origin of supplies usually located in various countries but also, in many cases, outside the European Union. The latter characteristic raises the question of the comparability of NG qualities and related constraints.[9]

A third characteristic comes from the fact that NG, again in contrast to electricity, can be routed to some extent through specific paths, and even re-routed in case of necessity if transportation facilities are equipped to be operated in reverse flow mode.

Finally, the product is storable, either compressed or liquefied, in the line pack or in underground storage facilities, usually depleted sites, salt cavities or aquifers.

Methodological issues

The subject of investments in NG transmission infrastructure is largely covered by various recent surveys conducted on behalf of either TSOs or institutional organizations. In some cases, the problem of corresponding investments is also investigated.

However, as far as the sector is concerned, the latter studies often fail to address:

- a fully integrated approach at EU27 level;
- the link between macroeconomic development and gas demands.

For these reasons, the proposed methodology is based on two complementary approaches:

- first, the analysis and review of the available documentation in the field of development projects related to the NG network at EU27 level;
- second, an attempt to reconcile available figures in line with the most recent output of the PRIMES model up to 2030[10] (also covered in Chapter 5).

Due to the specificity of the NG sector, the following sections will be dedicated to a preliminary introduction related to the EU27 economic outlook in the energy sector. Wherever possible, we will try to analyse the situation in line with the main components of the transmission system, ie:

- network capacities
- pipelines and LNG imports
- NG storage
- reverse flows

Uncertainty

It should be noted that a forecasting exercise with a time horizon of two decades remains highly speculative, with a lot of uncertainty surrounding future development of prices and demand.

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[9] Referring eg to the heat value and the Wobbe index. In some cases, NG sources cannot be mixed up as it is the case in Belgium and Netherlands operating two specific gas grids (Low HV and High HV).

[10] EU Energy Trends to 2030: Update 2009 (baseline 2009 and reference scenario 2009). A detailed description of these scenarios and their assumptions is available at http://ec.europa.eu/energy/studies/index_en.htm .

While some components of supply, such as transmission capacities in the main supply corridors, can be evaluated at an acceptable level of accuracy, the situation is less clear in the case of reverse flows or storage capacities. The gas network is operated as a system responding to the market needs. Hence the need for mutual adjustments is hard to anticipate.

4.2 Market balancing in the long run

Demand The most recent available data suggest that EU27 natural gas demand in 2008 was 517bcm/yr[11] (446 Mtoe/yr)[12]. However, there is a large amount of uncertainty about the level of future demand. Up until 2020, there is a convergence between available forecasts, although the financial and economic crisis has led to more recent downward revisions. Prior to the crisis, all forecasts ranged from 550 bcm/yr to 660 bcm/yr[13] (474 – 569 Mtoe/yr), although the 2009 PRIMES baseline is slightly lower.

The base case used for this chapter is the *‘EU Energy Trends to 2030: Update 2009’* reference scenario, which gives still lower 2020 forecasts given the higher renewables penetration. However, in certain cases, data from the *‘European Energy and Transport Trends to 2030: Update 2007’* have also been used (Appendix VII, Figure 7.1.2 shows 2007 results).

Between 2020 and 2030 larger divergences are observed. The lowest forecast is 550 bcm/yr (474 Mtoe/yr) while the highest forecast reaches 750 bcm/yr (647 Mtoe/yr). In the PRIMES 2007 reference scenario where the renewable targets are met, demand for gas is significantly lower still.

Supply The origins of NG imports are concentrated. From a total of 310 bcm/yr (267 Mtoe/yr) in 2006 (the most recent year of disaggregated data available), 84% of supplies to the EU27 came from just three countries[14]:

- in the east: Russia (42%)
- in the north: Norway (24%)
- in the south: Algeria (18%)

Other suppliers included Nigeria, Libya, Egypt, Trinidad and Tobago as well as other countries. All of these suppliers accounted for less than 5% of EU27 NG imports in recent years.

A recent study forecasts gas imports potential to the EU[15]. The results of this study are detailed in Table 4.1:

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[11] Estimation provided by EUROGAS, in a Press release: ‘Natural gas consumption in EU 27, Turkey and Switzerland, Brussels, 12/03/2009. This includes the demand covered by local production and importations.

[12] With a conversion factor of 1 Mtoe=1.16 bcm. The tables in this chapter are presented in bcm as the capacities are determined by volume rather than energy content. Equivalent tables presented in mtoe are available in Appendix VIII.

[13] Advice on the Opportunity to Set up an Action Plan for the Promotion of LNG Chain Investments - Economic, Market, and Financial Point of View -; FINAL REPORT; Chair of Energy Economics and Public Sector Management, Dresden University of Technology; MVV Consulting, May 2008. Based on data from DG TREN, IEA, WETO.

[14] EUROSTAT, Statistical Pocket Book, 2009.

[15] OME. Study on Interoperability of LNG Facilities and Interchangeability of Gas and Advice on the Opportunity to Set-up an Action Plan for the Promotion of LNG Chain Investments, FINAL REPORT, May 2008, DG TREN Framework Contract: TREN/CC/05-2005, lot 3, Technical Assistance in the Fields of Energy and Transport, Contract Awarded to MVV Consulting under the Contract number S07.78755; Contract duration from 02/01/2008 to 30/04/2008.

TABLE 4.1: ESTIMATIONS OF FUTURE GAS IMPORT POTENTIAL

Origin (in bcm)	2010	2020	2030
Russia/ Central Asia	166	196	207
Norway	94	95	100
Algeria	81	110	115
Libya	12	25	38
Egypt	28	28	28
Trinidad & Tobago/ Venezuela	6	6	6
West Africa	21	38	45
Iraq	20		
Qatar/UAE/Oman/Yemen	4	68	88
Iran		35	35
Azerbaijan/Turkmenistan		13	13

Source(s): OME.

These figures suggest that the dependency towards Russian, Norwegian[16], Algerian, Libyan and West African suppliers will increase until 2020 at least. This trend will be accompanied by rapid development of imports from the Arabian peninsula. However, a relative stabilization of imports will be observed over the period 2020-30 as regards ‘historical’ suppliers (Norway, Russia, Algeria and Egypt). Part of these flows will be imported through existing transportation facilities (such as Norway, Russia and Algeria), with some of them being renovated or upgraded in the meantime. In some cases, it is anticipated that supplies coming from eastern European and Maghreb countries will use new routes for which development is planned e.g. Nabucco, South Stream, Galsi, Medgas, Nord Stream pipelines.

Pipeline supply

A study issued in 2008 shows that average current maximum pipeline utilization rates[17] for the year 2007 were:

- Russia & Ukraine: 70%
- Algeria: 76%
- Libya: 92%
- Norway: 76%

The average utilisation rate is estimated at 73%.

LNG supply

However, it is anticipated that LNG will play a growing role in the coverage of EU27 demand. This is not only explained by the supply diversification and the anticipated development of far remote gas fields, especially in Africa and in the Middle East, but also for security purposes in terms of storage capacity[18].

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[16] Last available data concerning the natural gas importation potential from Norway suggests that the latter could even reach 105-120 bcm in 2020 (source: European Commission).

[17] TEN - ENERGY Priority Corridors for Energy Transmission; Part One: Legislation, Natural Gas and Monitoring; prepared by Ramboll A/S and Mercados SA; November 2008.

[18] 1m³ LNG=580 m³ gas, easily stored in the tanks of the NG regasification terminals.

The same study[19] indicates that the average utilization rate of LNG terminals is 48%, broken down as follows:

- Belgium (Zeebrugge): 38%
- France (Fos, Montoir): 71%
- Spain (Barcelona, Cartagena, Huelva, Bilbao,Saqunto, Mugardos): 45%
- Portugal (Sines): 39%
- Italy (Panigaglia): 51%
- Greece (Revythoussa): 38%
- United Kingdom (Isle of Grain, Milford): 26%

Import capacity

Combining the figures above, the maximum import capacity to the EU through the pipeline network (at 100% utilisation) reaches 391.2 bcm (337 Mtoe) per year. The latter data can be complemented by the additional import capacity of LNG terminals which is 99.4 bcm (86 Mtoe) per year.

However, unless the existing import pipelines and LNG terminals are operated with higherutilisation rates, the maximum capacity will not be achieved. The current annual flow is around 283.6 bcm (244 Mtoe) plus 47.3 bcm (40.78 Mtoe) respectively (data 2007).

Clearly as a technical constraint, the maximum load factor must be lower than 100%. We discuss what a realistic maximum load factor may be later in this chapter.

Entry points and major routes

Table 4.2 depicts the major entry points in Europe.

In the field of pipeline routes, main entry points are, in turn[20]:

- Slovakia: 108 bcm/yr (93 Mtoe/yr)
- Germany and the Netherlands (via Emden): 43.9 bcm/yr (38 Mtoe/yr)
- United Kingdom: 41.9 bcm/yr (37,84 Mtoe/yr)
- Italy: 41.7 bcm/yr (36 Mtoe/yr)
- Romania: 41.5 bcm/yr (36 Mtoe/yr)
- France: 18.6 bcm/yr (16 Mtoe/yr)
- Belgium: 14.6 bcm/yr (13 Mtoe/yr)
- Hungary: 14.3 bcm/yr (13 Mtoe/yr)
- Lithuania: 10.5 bcm/yr (9 Mtoe/yr)

As far as LNG regasification terminals are concerned, countries are, respectively:

- Spain: 54.4 bcm/yr (47 Mtoe/yr)
- France: 18.3 bcm/yr (16 Mtoe/yr)
- Belgium: 8.4 bcm/yr (7 Mtoe/yr)
- United Kingdom: 5.5 bcm/yr (5 Mtoe/yr)
- Italy: 4.7 bcm/yr (4 Mtoe/yr)

As above, the total import capacity for both types of supplies, at 100% utilisation rates, amounts to 490 bcm/yr (422 Mtoe/yr; data 2007).

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[19] TEN - ENERGY Priority Corridors for Energy Transmission; Part One: Legislation, Natural Gas and Monitoring; prepared by Ramboll A/S and Mercados SA; November 2008.

[20] TEN - ENERGY Priority Corridors for Energy Transmission; Part One: Legislation, Natural Gas and Monitoring; prepared by Ramboll A/S and Mercados SA; November 2008. Attention should be paid to the fact that the present list does not explicitly take into consideration the gas imported from the Siberian fields through the Yamal gas pipeline operated by Gazprom through the Polish border. The latter inlet has an announced total capacity of 33 bcm/yr.

TABLE 4.2: CAPACITIES OF MAIN EU SUPPLY ROUTES

Max flow in bcm/ yr	Type	BE	DE/NL	ES	FI	FR	GR	HU	IT	LT	LV	PL	PT	RO	SK	UK	Total	%
Russia	Pipelines				7.0			14.3		10.5	1.3	36.6			108.0		177.7	36.2%
Ukraine	Pipelines											5.7		41.5			47.2	9.6%
Algeria	Pipelines			11.1					31.7								42.8	8.7%
Norway	Pipelines	14.6	43.9			18.6											77.1	15.7%
Libya	Pipelines								10.0							36.4	46.4	9.5%
Subtotal	Pipelines	14.6	43.9	11.1	7.0	18.6	-	14.3	41.7	10.5	1.3	42.3	-	41.5	108.0	36.4	391.2	79.7%
Other imports	LNG terminal	8.41		54.4		18.31	2.1		4.7				6.0			5.5	99.4	20.3%
Grand total		23.0	43.9	65.5	7.0	36.9	2.1	14.3	46.4	10.5	1.3	42.3	6.0	41.5	108.0	41.9	490.6	100.0%
%		4.7%	8.9%	13.4%	1.4%	7.5%	0.4%	2.9%	9.5%	2.1%	0.3%	8.6%	1.2%	8.5%	22.0%	8.5%	100.0%	

Source(s): T E N - ENERGY Priority Corridors for Energy Transmission; Part One: Legislation, Natural Gas and Monitoring; prepared by Ramboll A/S and Mercados SA; November 2008.

The main countries where imports arrive are (% of EU total):

- Slovakia: 22%
- Spain: 13.4%
- Italy: 9.5%
- Germany/Netherlands (via Emden): 8.9%
- Poland: 8.6%
- Romania: 8.5%
- United Kingdom: 8.5%
- Belgium: 4.7%

The situation of Spain and the United Kingdom remains specific as injection capacities address mainly the supply of their national markets, rather than the EU as a whole, due to their specific location and situations.

In the case of Spain, the situation may change in the future due to the foreseeable impact of the MEDGAZ project. For the United Kingdom, transit capacities will be limited by the expected NG dependency with the ongoing exhaustion of national deposits.

Links with the PRIMES projections

The projections from PRIMES 2007 are reasonably moderate in terms of consumption growth rates until 2020 at least (Appendix VII; figure 7.1.2) but they are more ambitious in terms of energy dependence, ie in terms of increased imports. They can be compared to the most ambitious scenarios at the 2020 and 2030 horizons (Appendix VII; figure 7.6.6 and figure 7.1.3 respectively).

Table 4.3 shows the projections presented by the PRIMES 2007 baseline. The expected increase could achieve 9.2% and 11.5 % in volume of gross inland consumption at the 2020 and 2030 horizons respectively[21] (see also Appendix VII; Table 7.8.1). Although the 2010 reference case shows lower levels of gross inland consumption (due to a combination of the economic crisis and increased renewables penetration) there is still an increase in net imports as domestic supplies fall.

TABLE 4.3: PROJECTIONS FROM THE PRIMES 2007 BASELINE

	2010	**2020**	**2030**
Gross inland consumption	462,439	504,897	515,822
Growth last decade GIC		9.2%	2.2%
Growth from 2010 of GIC		9.2%	11.5%
Net Imports	294,225	389,963	431,447
Growth last decade of N. Imp.		32.5%	10.6%
Growth from 2010 of N. Imp.		32.5%	46.6%
Imports/ consumption	63.6%	77.2%	83.6%

Source(s): EUROPEAN ENERGY AND TRANSPORT TRENDS TO 2030 — UPDATE 2007; EU-27 ENERGY BASELINE SCENARIO TO 2030; European Commission: Directorate-General for Energy and Transport; April 2008, own recalculation.

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[21] EUROPEAN ENERGY AND TRANSPORT TRENDS TO 2030 — UPDATE 2007; EU-27 ENERGY BASELINE SCENARIO TO 2030; European Commission: Directorate-General for Energy and Transport; April 2008; own recalculation. The most recent figures from the 2010 projections are also used in the analysis, but these are not yet published.

If the variation is quite substantial during the period 2010-20, it should be lower during 2020-2030. This reflects the anticipated impact of energy savings, higher generation efficiencies as well as the evolution of the energy mix, in line with the expected development of RES.

The situation is different if we look at the total net imports. The figures suggest that imports of gas could be 32.5% higher in 2020 than in 2010, and 46.6% higher in 2030. Hence, there is a clear need to reinforce transmission capacities in the medium and long run.

The latter data involves the gradual decay of exploited deposits which, located inside the EU27, currently cover, or have been covering, a substantial part of the member states needs, particularly in the United Kingdom and the Netherlands. The data show the increasing dependency of member states on imported NG which is expected to exceed 80% of consumption by 2030 according to the projections from the PRIMES model.

Pipeline load factors

To be consistent with other outputs, the pipeline utilization load factors would not exceed 72% if all other things are the same (see Appendix VII; table 7.3). However, this estimation must be appreciated in light of the following issues:

- the depletion of some NG deposits outside the EU and the subsequent relocation of supply routes
- the depreciation of existing infrastructure and the subsequent needs for replacement
- the political aspects related inter alia to:
  - the internal market development
  - the security of supplies
  - the development/implementation of new alternative types of infrastructure (such as new storage capacities and/or LNG terminals, reverse flow equipments)

TABLE 4.4: ENTSOG PEAK DAY POTENTIAL SUPPLY VS ENTSOG PEAK DAY DEMAND

Mio. Nm^3/day	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Pipeline import	1,156	1,154	1,265	1,358	1,381	1,381	1,381	1,381	1,381	1,381
Storage	993	1,043	1,086	1,118	1,145	1,241	1,295	1,323	1,329	1,333
Production	863	894	884	850	818	774	743	719	687	659
LNG	473	494	554	583	618	672	682	687	695	695
Sum	3,485	3,585	3,789	3,909	3,939	4,068	4,101	4,110	4,092	4,068
% to 2010	100	103	109	112	113	117	118	118	117	117
ENTSOG peak day demand scenario	3,115	3,188	3,253	3,308	3,356	3,399	3,432	3,448	3,463	3,475

Source(s): European Ten Year Network Development Plan; 2010 – 2019,December 2009 (Ref. 09ENTSOG).

Specific attention must be paid to the fact that some of the available data refer to peak flows, for instance the data in a recent study issued by ENTSOG[22].The reported data show a relative stabilisation of peak demand forecasts after 2015. Table 4.4 illustrates this issue.

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[22] European Ten Year Network Development Plan; 2010 – 2019,December 2009 (Ref. 09ENTSOG).

We observe in Table 4.4 above that regional production plays a decreasing role in the coverage of the peak flows up to 2019.

The balance is provided partially by pipeline imports but also, and to a larger extent, by LNG and the development of the storage capacities which, whether they are driven from underground storage facilities or peak shaving LNG storages, can cover up to 33% of the total peak demand.

4.3 Identification of the main projects

Gas transportation corridors

Current transit countries inside the EU are important for cross border transmission capacities.

They are located at the main injections gates ie the borders of eastern European countries, of the North Sea region and of southern Europe.

As indicated in Figure 4.1, transit corridors are located in the following countries:

- Austria
- Belgium
- Germany
- Hungary
- Italy
- Netherlands
- Poland
- Slovakia

The roles of Italy, Bulgaria, Romania and Hungary, as well Austria, are likely to increase after the completion of Nabucco and Galsi pipelines. In the north of Europe, Germany would be targeted by the Nord Stream pipeline development.

Figure 4.1: Existing and planned major European pipeline routes[23]

Background

We distinguish separately development projects in the field of pipeline transmission capacities, LNG re-gasification terminals, storage and reverse flows.

First, the output of the most recent studies and available documentation is analysed. Second, an additional highlight in line with recent results from the PRIMES model is provided. The emphasis will be put at this level on the identification of capacities and corresponding projects. The financial impacts are assessed in a separate section.

The current peak day demand was estimated in a recent survey[24] to be around 3,100 Nm³/day (see Table 4.4 and Figure7.6.1 in Appendix VII). By 2020, this amount is expected to rise to around 3,500 Nm³/day.

The forecasted increase in demand could be theoretically covered by the existing network capacities given the current load factor of pipelines and re-gasification terminals that are below 100% (see below). However, for safety and operating reasons as well as for the purpose of taking into consideration peak demand scenarios, the network cannot in practice be used at 100% capacity, meaning that new capacity is required.

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[23] Source: GSE storage map 2008. In DG TREN C1; Study on natural gas storage in the EU, Draft Final Report, October 2008.

[24] European Ten Year Network Development Plan; 2010 – 2019, December 2009 (Ref. 09ENTSOG).

Pipelines

In the case of pipelines, the current situation is such that 73% of the total transmission capacity is exploited (see Section 4.2). Keeping a target of 80% in the medium and long run is suggested in Appendix VII: Table 7.6.3.[25]

For this reason, it would be necessary to upgrade the existing infrastructure.

For the same time horizon (2019), the additional demand will be covered as follows (see Appendix VII: Figure 7.6.5 vs ENTSOG Annual Demand Scenario[26]):

demand scenario:	600 bcm/year (517 Mtoe/yr)
existing capacities and FID:	600 bcm/year (517 Mtoe/yr)
mature projects:	50 bcm/year (43 Mtoe/yr)
new projects	100-120 bcm/year(86-104 Mtoe/yr)

New projects involve the Galsi, ITGI, South Stream, Nabucco and White Stream pipelines. However, there is a question as to whether all of these projects will be constructed.

The underlying scenario anticipates a relative stabilization of demand and related imports after 2015. Peak off-take is expected to stabilize at 3,750 mcm/day (Appendix VII; Figure 7.6.5[27]).

Beyond 2020

The ENTSOG study considers the period up to 2019, but another study that covers a longer forecasting period[28] suggests that in 2030 net imports could reach 463 bcm/year (399 Mtoe/yr) in the EU30[29] (Appendix VII: Figure 7.6.6). With a load factor of 80%, ie with 20% security, the pipe transmission system should be calibrated for a target flow of 555 bcm/yr (478 Mtoe/yr). The figures remain below those announced in the above mentioned ENTSOG study but they correspond to steady flows and not to peak flows.

Specific projects

Based on the latter data (Appendix VII, Table 7.7.5), predictions of completion dates of considered projects or projects under implementation up until 2016 is presented in Table 4.5.

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[25] In DG TREN C1; Study on natural gas storage in the EU, Draft Final Report, October 2008.

[26] European Ten Year Network Development Plan; 2010 – 2019, December 2009 (Ref. 09ENTSOG).

[27] European Ten Year Network Development Plan; 2010 – 2019, December 2009 (Ref. 09ENTSOG).

[28] Energy Infrastructure Costs and Investments between 1996 and 2013 (medium-term) and further to 2023 (long-term) on the Trans-European Energy Network and its Connection to Neighboring Regions with emphasis on investments on renewable energy sources and their integration into the Trans-European energy networks, including an Inventory of the Technical Status of the European Energy-Network for the; Year 2003; Contract n. TREN/04/ADM/S07.38533/ETU/B2-CESI; Issue Date: October 2005; Prepared by: CESI spa (Centro ElettrotecnicoSperimentaleItaliano) – Italy, IIT (Instituto de InvestigaciónTecnológica) – Spain, ME (MercadosEnergeticos) – Spain, RAMBØLL A/S – Denmark; October 2005.

[29] EU30 was defined in the paper as the EU member states plus Norway, Switzerland and Turkey.

TABLE 4.5: CAPACITY FORECASTS OF SUPPLY ROUTES UNDER DEVELOPMENT

Capacity (bcm/yr)	2010	2011	2012	2014	2016	Total
Pipeline mix	8					8
Pipeline offshore	55	5	8		32	100
Pipeline onshore			8	36		44
Total	63	5	16	36	32	152

Source(s): Energy Infrastructure Costs and Investments between 1996 and 2013 (medium-term) and further to 2023 (long-term) on the Trans-European Energy Network and its Connection to Neighbouring Regions with emphasis on investments on renewable energy sources and their integration into the Trans-European energy networks, including an Inventory of the Technical Status of the European Energy-Network for the; Year 2003; Contract n. TREN/04/ADM/S07.38533/ETU/B2-CESI; Issue Date: October 2005; Prepared by: CESI spa (Centro ElettrotecnicoSperimentaleItaliano) – Italy, IIT (Instituto de InvestigaciónTecnológica) – Spain, ME (MercadosEnergeticos) – Spain, RAMBØLL A/S – Denmark; October 2005.; Various sources including projects presentations and web sites www.nabucco-pipeline.com, www.nord-stream.com, www.igi-poseidon.com; own calculation.

This would imply an overall capacity of 152 bm³/year (131 Mtoe) if all projects are effectively implemented. Most of the transportation capacities are provided by offshore routes.

LNG terminals

Various projects of re-gasification terminals are identified. Some are already under implementation as indicated in Figure 7.6.7, Appendix VII[30].

The available data relate to the planned LNG and related peak shaving storage projects over the period 2010-2020; they are summarisedin Tables 4.6, 4.7 and 4.8.

TABLE 4.6: BREAKDOWN OF NEW LNG PROJECTS STATUS

Send out capacity (bm^3/yr)	After extension	Existing after extension	Proposed	Under construction	Total
2010		20.8	9.0	16.0	45.8
2011		17.8	19.0	44.3	81.1
2012			14.2	2.0	16.2
2013	7.3		9.0		16.3
2014		36.5	27.4		63.9
2015		11.8	8.0		19.8
N/A		16.5	10.8		27.3
Total	7.3	103.4	97.4	62.3	270.3

Source(s): GLE map& data base, own calculation.

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[30] Source OME. Study on Interoperability of LNG Facilities and Interchangeability of Gas and Advice on the Opportunity to Set-up an Action Plan for the Promotion of LNG Chain Investments, FINAL REPORT, May 2008, DG TREN Framework Contract: TREN/CC/05-2005, lot 3, Technical Assistance in the Fields of Energy and Transport, Contract Awarded to MVV Consulting under the Contract number S07.78755; Contract duration from 02/01/2008 to 30/04/2008.

For 2013, Table 4.6 indicates only the incremental capacity while for the other years the reported figures cover the target send-out capacity after extension.

It is important to note the 62.3 bcm/yr (54 Mtoe/yr) capacity is currently under construction. The total capacity for projects under consideration, but not yet under construction, is 97.4 bcm/yr (84 Mtoe/yr).

TABLE 4.7: BREAKDOWN OF SEND-OUT CAPACITIES FOR NEW LNG PROJECTS

Send out capacity (bm^3/yr)	2010	2011	2012	2013	2014	2015	N/A	Total
DE							10.8	10.8
ES		24.8	2.0	7.3	28.5	11.8		74.4
FR				9.0	9.0	8.0	16.5	42.5
GR								-
IT	25.0	19.8	13.0		8.0		-	65.8
LT								-
NL		31.0			13.0			44.0
PL			1.2		-			1.2
PT		5.5						5.5
RO							-	-
SE							-	-
UK	20.8				5.4		-	26.2
Total	45.8	81.1	16.2	16.3	63.9	19.8	27.3	270.3

Source(s): GLE map & data base, own calculation.

Table 4.7 indicates the expected location of corresponding projects, all status mixed.

The main countries involved are Spain, Italy, the Netherlands, France and the United Kingdom. However, as capacities are already developed in Spain and in France, expected new developments will probably take place in Italy, the Netherlands and the United Kingdom.

Table 4.8 shows the evolution of additional storage capacities linked to these LNG projects. It is clear that in the field of peak shaving storage, most of extensions that are under consideration will be implemented before 2015.

TABLE 4.8: BREAKDOWN OF STORAGE CAPACITIES FOR NEW LNG PROJECTS

Storage (m^3 LNG)	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**N/A**	**Total**
DE								-
ES		4,200,000	3,000,000	300,000	1,340,000	760,000		9,600,000
FR							360,000	360,000
GR								-
IT	940,000	857,000			240,000			2,037,000
LT								-
NL		540,000			376,000			916,000
PL								-
PT		390,000						390,000
RO								-
SE								-
UK	1,000,000							1,000,000
Total	1,940,000	5,987,000	3,000,000	300,00	1,956,000	760,000	360,000	14,303,000

Source(s): GLE map & data base, own calculation.

Another study[31] reports the following priorities in the field of new terminals development (Appendix VII; Table7.7.6):

- Spain: Mugardos (2 bcm/yr) (1.7 Mtoe/yr)
- Italy: Tuscany region (6 bcm/yr) (5.2 Mtoe/yr)
- Italy: North Adriatic coast (8 bcm/yr) (6.9 Mtoe/yr)
- France: undetermined (9 bcm/yr) (7.8 Mtoe/yr)

These new investments should be complemented by storage capacities and extension projects for two existing facilities:

- Belgium: Zeebrugge (10 bcm/yr) (8.6 Mtoe/yr)
- France: Fos-sur-Mer (8 bcm/yr) (6.9 Mtoe/y)

Attention should be paid to the fact that some of the announced projects seem to reach low economies of scale in terms of injection capacity (e.g. Mugardos).

These investments are expected to take place when the gas demand reaches the gas import capacity – the pipelines are calculated with a load factor of 80% and LNG re-gasification terminals with a load factor of 60%. The latter load factor is below the previous one mentioned for pipelines. This seems realistic not only because of the logistics constraints but also the way in which LNG terminals operate.

The results from this study suggest that the incremental NG import capacity provided by these six projects would be 43 bcm/yr (37 Mtoe/yr).

NG storage

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[31] Energy Infrastructure Costs and Investments between 1996 and 2013 (medium-term) and further to 2023 (long-term) on the Trans-European Energy Network and its Connection to Neighbouring Regions with emphasis on investments on renewable energy sources and their integration into the Trans-European energy networks, including an Inventory of the Technical Status of the European Energy-Network for the; Year 2003; Contract n. TREN/04/ADM/S07.38533/ETU/B2-CESI; Issue Date: October 2005; Prepared by: CESI spa (Centro ElettrotecnicoSperimentaleItaliano) – Italy ,IIT (Instituto de InvestigaciónTecnológica) – Spain, ME (MercadosEnergeticos) – Spain, RAMBØLL A/S – Denmark; October 2005.

NG gas can be stored in depleted fields, aquifers, salt cavities and LNG peak shaving reservoirs (Appendix VII; Figure 7.5.4).

In the case of LNG peak shaving reservoirs, a complementary peak shaving storage can be available in LNG re-gasification plants, providing a marginal capacity. Other storage capacities are provided by underground storage infrastructure.

Depleted fields provide almost 70% of the existing storage capacities and could maintain this position in the long run[32]. The possibility to develop such facilities depends directly on the geological context. Unfortunately, storage sites are not always located near transmission pipelines and/or gas markets. In the EU27, France, Germany and Italy currently share 37% of the 80 bcm/yr (69 Mtoe/yr) total estimated capacity (Appendix VII; Figure 7.5.1)[33].

The long-run prospects very much depend on the location of favorable sites mostly concentrated in the following regions (Appendix VII; Figure 7.5.2)[34]:

- Latvia: > 30 bcm (26 Mtoe)
- Ukraine-Slovakia border: > 80 bcm (69 Mtoe)
- Romania: < 30 bcm (26 Mtoe).
- North Sea[35]: > 60 bcm (52 Mtoe)

The reported data concern the distribution of depleted fields. This represents two thirds of the possible storage developments (see above). A breakdown by country clearly indicates that those countries located in the south western European regions have a storage capacity deficit compared to the other regions (Appendix VII; Table 7.5.3)[36].

Table 4.9 shows expected storage extension capacities up to 2020.

We observe in this table that most extension facilities:

- are expected to take place up to 2015
- are either committed or planned
- concern depleted fields (offshore and onshore)

Detailed information on the scope and location of projects under review is presented in Appendix VII; Table 7.6.8.

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[32] GSE.

[33] The role of natural gas storage in the changing gas market landscape. Jean-Marc Leroy, GSE President, CEO of Storengy, 24th World Gas Conference, Argentina, 5-9 October 2009.

[34] GSE Storage maps. In DG TREN C1; Study on natural gas storage in the EU, Draft Final Report, October 2008.

[35] There are two suggested north sea sites, each of 30bcm or more.

[36] GSE, ERDGAS KOHLE 122, Jg. 2006, Heft 11.

TABLE 4.9: STORAGE INVESTMENT PLANNING FORECASTS (Mcm)

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2020**	**N/A**	**Total**
Committed			30	4,465	1,005	616	1,215	180	525				250	300	8,586
N/A														830	830
Planned				2,920	1,895	5,310	12,035	180	18,425	2,500	160	1,250			44,675
Under construction		110	420	4,612	2,332	60	2,230		559			820		400	11,543
Total		110	450	11,997	5,232	5,986	15,480	360	19,509	2,500	160	2,070	250	1,530	65,634

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2020**	**N/A**	**Total**
Expansion		110	30	2,657	1,482	1,738	1,295	180	2,229			420		430	10,571
New facility			420	9,340	3,521	4,248	14,185	180	17,280	2,500	160	1,650	250	1,100	54,834
Reparation					229										229
Total		110	450	11,997	5,232	5,986	15,480	360	19,509	2,500	160	2,070	250	1,530	65,634

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2020**	**N/A**	**Total**
Aquifer			30	1,450		60	3,200		370						5,110
Depleted field				7,777	3,568	1,530	10,965		16,049			1,250		1,500	42,639
LNG peak shaving				175	172	436			525						1,308
N/A							795								795
Salt cavity		110	420	2,595	1,492	3,960	520	360	2,565	2,500	160	820	250	30	15,782
Total		110	450	11,997	5,232	5,986	15,480	360	19,509	2,500	160	2,070	250	1,530	65,634

Source(s): Data GSE; own calculation.

Reverse flows

Although large storage potential is located in central Europe (140 bcm (121 Mtoe); see above) and possibly outside the EU27 (Ukraine), the question of security of supply on the one hand, and the ongoing development of LNG terminals as well as storage sites in western Europe on the other, increase the need for strengthening the interoperability of the existing NG network.

This implies upgrading compressing stations and control systems for reverse mode use. Reverse flow projects do not usually cover larger investments and can be rather quickly implemented.

The review of the reverse flow projects identified by GTE confirms that the bulk of investments will be realized before the end of 2011, ie in the short term (Table 4.10). A large share of the projects is currently under implementation.

TABLE 4.10: NUMBER OF IDENTIFIED REVERSE FLOW PROJECTS

	2010	**2011**	**2012**	**2013**	**2015**	**N/A**	**Total**
Engineering	2	1			1	1	5
Feasibility				2		4	6
Implementation	5	2	2	1	1		11
In preparation	1	1	2				4
N/A						3	3
Planned		4				1	5
Ready for implementation	6						6
Under decision	1	4		1			6
Total	15	12	4	4	2	9	46

Source(s): CAPEX for Capital Expenditures: Source: GTE+ Reverse Flow Study TF, Technical Solutions, 21 July 2009, own calculations.

Another issue is the recalculation of the transmission flow corresponding to the transmission mode after full completion. No consolidated information is available at this stage. However, we may reasonably anticipate that reverse flow volumes will be impacted by the development of LNG re-gasification terminals in western and southern European countries as well as by the ongoing development of new storage sites. More information on the scope and location of reverse flow projects is detailed in Appendix VII; Table 7.6.9.

Remarks on market-integration investments

The issue of intra-EU connections can be addressed at two levels, taking into account the commercial aspects and the security of supply.

The latter aspect focuses on the capacity to shift suppliers in case of emergency, or a disruption to transport capacities. There are three possible approaches:

- Alternative supply routes - They are addressed respectively through the diversification of onshore corridors and related pipelines (such as the Nord Stream interconnector) and LNG terminals.
- Storage capacities - They include both underground storage and peak-shaving plants, usually related to re-gasification terminals.

- Gas network interoperability - The increase of reverse flow capacities is related to this specific issue and the ability to use medium-term alternative supplies or short-term storage utilization.

All of these are covered in the investment scenarios at least to the extent of the possibility to improve the current situation through a set of specific actions. However, providing a comprehensive answer to the issue of system security and interoperability would require an integrated modelling approach[37] which falls beyond the scope of the present study.

Impacts of RES

The impact of RES on network utilization rates in the gas sector should also be taken into account. Overall, in the sector, our suggested outcomes could be summarized as:

- At most relatively slow growth in primary energy consumption in Europe, although faster growth outside Europe. This is taken into consideration in the energy balances of the PRIMES projections.
- A possible increase in peak flows as most RES envisaged need 100% back-up, which partially depends on gas consumption (ie a higher variance in flows).

However, as far RES are concerned, the impact will be relatively small overall and is not comparable in size to that suggested for the electricity sector. There are several reasons for this, including:

- The utilization of storage capacities available to the gas sector (some of which are currently under development).
- The utilization of alternative back-up energy sources that can be activated as and when required.
- The still limited impact of RES (eg the objective of 20% in 2020).

4.4 Next steps

The findings for demand for gas, supply, and the gas infrastructure requirements in the EU27 were incorporated in the analysis of investment costs.This analysis is presented in the following chapter.

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[37] This includes, inter alia, the modelling of the integrated gas grid at EU27 level and scenarios with disruptions to the main supply routes.

5 Analysis of InvestmentNeeds

5.1 Introduction

In this chapter we consider, in terms of investment costs, the infrastructure requirements that were identified by the analysis described in Chapters 3 and 4. We start with the electricity sector and then consider the gas sector.

In the case of electricity the estimates of investment costs based upon evidence drawn from the literature review were not considered sufficiently robust[38]; we therefore use the results of the KEMA/ICL modelling of the interconnection, offshore wind integration and additional generation investments.

In the case of gas, our starting point is the planned infrastructure that was identified in Chapter 4, which is then compared against the projections of demand. Our investmentcosts are estimated based on these identified projects plus any additional requirements.

5.2 KEMA/ICL investment assessment in the electricity sector

The results of the KEMA/ICL modelling are presented at a summary level and at a Member State level.The results show the various investment requirements from the integration of offshore wind, interconnection between member states and the additional investments required in additional generation capacity to ensure that the historic levels of system security can be maintained.This generation capacity is additional to the investment required to establish the generation in the defined scenarios.

Uncertainties

There are significant uncertainties for the many inputs that underpin this modelling exercise due to the 20 year modelling horizon.Changes in the generation capacity mix, demand forecast, or the expansion factors that determine investment costs could have a significant impact on the outputs.The calculated investment levels correspond to a series of future projects, some of which will inevitably exhibit higher or lower expansion factors than used in the modelling.It is assumed that such errors will to some extent offset each other and that the error for these aggregate cost outputs could be in the range of +/-15%.

Total electricity investment requirements

Table 5.1provides a summary of total electricity infrastructure investment requirements for each of the modelled scenarios in 2020 and 2030 split according to offshore wind (and CSP) network infrastructure, interconnection and additional generation capacity.

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[38] Based on the projectsidentified in the literaturereview, and using a calculation method based on unit costs as identified in the literature, total investmentcosts up to 2030 wereestimated to be in the range of €5 bn to €35 bn.

TABLE 5.1: SUMMARY OF ELECTRICITY INFRASTRUCTURE REQUIREMENTS

Scenario	Offshore wind power network infrastructure (€bn)	Member State Interconnection Investment (€bn)	Additional generation investment for system reliability (€bn)	Annual operating cost (€bn)
PRIMES 2020	32.8	27.7	17.9	154.1
PRIMES 2030	50.4	28.1	41.7	160.1
High RES 2030	99.8	61.2	92.8	128.6

Commentary

The PRIMES 2030 reference scenario shows higher operating costs thanthe PRIMES 2020 reference scenario, which is due to an increase in electricity production to meet growing consumption, whereas there is a drop in operating cost for the High RES scenario with the same consumption.This fall in operating costs is due to the significant proportion of RES (near zero marginal cost) generation available to meet the 2030 consumption in the High RES scenario (around 49% production contribution from RES).

The PRIMES 2030 reference scenario shows greater additional generation investment, for two reasons:

- there is increased consumption;
- the value of providing security by sharing non-RES generation is insufficient to justify transmission investments leading to additional generation capacity investments by each member state, iethere is no sharing of additional thermal plants between Member States.

The High RES scenario sees greater transmission investment.This is economically justified by increasing the utilisation of the near zero marginal cost RES generation.The potential cost of curtailing the output from renewable generators is likely to be high, as these would need to be compensated and replacement generation scheduled.The difference between the cost of this additional generation and the zero marginal cost of operating existing RES improves the economics of transmission investment. This allows the economic benefit of capturing this low cost energy and also delivers the ability to utilise the transmission for supply security.

The High RES scenario requires higher additional generation than the PRIMES 2030 reference scenario.This is because there is a greater requirement for back-up generation to provide reserve for intermittent renewables.

5.3 MemberState results for electricity investment needs

The tables below show the disaggregation of the investment requirements by MemberState.The investment in transmission interconnection between Member States is assumed to be shared 50:50 between the countries at the two ends of the interconnection.The additional investment in generation is attributed directly to the

Member States where the modelling suggests it is required and is based on generation from low load factor, peaking plant[39].

TABLE 5.2: PRIMES 2020 (€m)

	Offshore integration investment (A/B)	Interconnection investment (C)	Additional generation investment (based on OCGT)
Austria	0	600	0
Belgium	900	500	1,050
Bulgaria	600	0	0
Cyprus	400	0	0
Czech Republic	0	100	350
Denmark	800	700	700
Estonia	500	300	0
Finland	700	1,900	350
France	4,100	2,900	1,400
Germany	4,300	2,300	3,150
Greece	600	400	0
Hungary	0	400	700
Ireland	500	200	0
Italy	1,100	1,500	0
Latvia	0	0	0
Lithuania	0	600	0
Luxembourg	0	100	0
Malta	300	0	0
Netherlands	1,600	2,300	700
Norway	600	4,500	1,050
Poland	700	200	350
Portugal	500	400	0
Romania	700	0	0
Slovakia	0	200	350
Slovenia	0	300	0
Spain	1,600	1,600	0
Sweden	600	2,400	1,050
Switzerland	0	100	350
United Kingdom	11,700	3,200	6,300
Total	32,800	27,700	17,850

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[39] It could be possible to change this from a low load factor peaking plant to a more mid to peaking plant e.g. to make it more economic for plant types such as a CCGT plant. This would require a mechanism to reduce other plants' utilisation to allow for the higher load factor for this back-up plant. An alternative to this would be to reduce the installed capacity in the system but this would lead to a reduction in system security. Adding additional transmission capacity would not be an appropriate solution to this, with transmission capacity being rarely utilised, needed only for system security purposes, which the modelling would suggest is not economically optimal.

The PRIMES 2020 interconnection investment costs are based upon the ENTSO-E TYNDP capacity increases, utilising KEMA expansion factors to derive investment costs.

TABLE 5.3: PRIMES 2030 (€m)

	Offshore integration investment (A/B)	Interconnection investment (C)	Additional generation investment (based on OCGT)
Austria	0	600	350
Belgium	900	500	1,750
Bulgaria	600	0	0
Cyprus	400	0	0
Czech Republic	0	100	700
Denmark	800	700	1,050
Estonia	500	300	0
Finland	700	1,900	1,400
France	5,700	3,000	9,450
Germany	14,300	2,400	6,650
Greece	600	400	0
Hungary	0	400	1,400
Ireland	500	200	0
Italy	1,100	1,500	0
Latvia	600	0	0
Lithuania	0	600	0
Luxembourg	0	100	350
Malta	300	0	0
Netherlands	1,600	2,300	2,100
Norway	1,900	4,500	1,750
Poland	700	300	2,100
Portugal	500	400	0
Romania	700	0	0
Slovakia	0	200	700
Slovenia	0	300	350
Spain	4,900	1,700	2,450
Sweden	600	2,400	1,750
Switzerland	0	100	350
United Kingdom	12,500	3,200	7,000
Total	50,400	28,100	41,650

TABLE 5.4: High RES 2030 (€m)

	Offshore integration investment (A/B)	Interconnection investment (C)	Additional generation investment (based on OCGT)
Austria	0	600	700
Belgium	1,800	2,000	2,450
Bulgaria	600	300	700
Cyprus	400	100	0
Czech Republic	0	300	2,800
Denmark	1,600	900	1,750
Estonia	500	300	350
Finland	700	1,900	2,800
France	11,800	15,200	23,100
Germany	26,200	4,200	15,750
Greece	600	800	1,050
Hungary	0	400	2,100
Ireland	1,000	300	1,050
Italy	1,100	1,500	3,150
Latvia	600	0	0
Lithuania	0	600	0
Luxembourg	0	100	0
Malta	300	100	0
Netherlands	3,700	4,300	2,450
Norway	3,100	4,500	350
Poland	700	900	5,950
Portugal	500	400	700
Romania	700	0	700
Slovakia	0	200	700
Slovenia	0	300	700
Spain	12,000	12,800	0
Sweden	1,300	2,400	4,200
Switzerland	0	700	0
United Kingdom	30,600	5,100	19,250
Total	99,800	61,200	92,750

Both the PRIMES 2030 and the High RES 2030 interconnection investment costs are based upon the ENTSO-E TYNDP capacity expansions planned up to 2020 plus the KEMA modelled capacity increases.The modelled capacity increases include only the investments required to provide for bulk transfer of energy between Member States.It is feasible that there may be additional investment requirements to resolve detailed physical power flow issues that are not considered by the KEMA/ICL modelling framework, e.g. voltage constraints, loop flow issues.

5.4 Investment needs in the gas sector

Introduction

Historic investment related to the gas transmission system in the EU30[40] ranged from €2,000m to €3,000m per year between 1996 and 2004 with an average exceeding €2,600m (Appendix VII; figure 7.7.1: EU 30). These estimates are carried out on the basis of reported investments from TSOs and, whenever required, estimation on their missing replies.

The same sources report a total investment of €23,700m during the same period (see Appendix VII; Figure 7.7.2). Figures from the same source suggest an increase to €24,100mper period for the mid-term forecast (2005-2013) and the long term forecast (2014-2023).However, parts of the identified investments in the field of pipeline infrastructure are located outside the EU (Appendix VII; Table 7.7.4).

Our assessment in Chapter 4 shows that there is a need for further investment in gas import capacity. Investment is expected to take place when gas demand reaches the gas import capacity – our assumption is that this is calculated with a load factor of 80% for pipelines and 60% for LNG regasification terminals (see Chapter 4).

In this section we consider the following:

1 - Supply pipelines and interconnectors
2 - NG network development (EU27)
3 - LNG regasification terminals
4 - Storage capacities
5 - Reverse flow projects

Total investment in pipelines

Tables 5.5, 5.6 and 5.7 present the expected capacities and investment costs of new pipelines. These include pipelines importing gas to the EU and pipelines between EU member states. All the figures are driven from Appendix VII, Table 7.7.5, although in these tables we exclude projects that were due for completion before 2010. The costs are taken from the estimated budgets for the pipelines.

Table 5.7 shows the investments made between countries; the rows and columns should be considered interchangeable (ie we are not saying that one or the other country is making the investment).

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[40] EU27 plus Norway, Switzerland and Turkey.

TABLE 5.5: PIPELINE CAPACITY BREAKDOWN PER TYPE OF PROJECT

Capacity (bcm/yr)	2010	2011	2012	2014	2016	Total
Pipeline mix	8					8
Pipeline offshore	55	5	8		32	100
Pipeline onshore			8	36		44
Total	63	5	16	36	32	152

Source(s): Energy Infrastructure Costs and Investments between 1996 and 2013(medium-term) and further to 2023 (long-term) on the Trans-EuropeanEnergy Network and its Connection to Neighbouring Regions withemphasis on investments on renewable energy sources and their integration into the Trans-European energy networks, including anInventory of the Technical Status of the European Energy-Network for the; Year 2003; Contract n. TREN/04/ADM/S07.38533/ETU/B2-CESI; Issue Date: October 2005; Prepared by: CESI spa (Centro ElettrotecnicoSperimentaleItaliano) – Italy, IIT (Instituto de InvestigaciónTecnológica) – Spain, ME (MercadosEnergeticos) – Spain, RAMBØLL A/S – Denmark; October 2005. Various sources including projects presentations and web sites www.nabucco-pipeline.com, www.nord-stream.com, www.igi-poseidon.com; own calculation.

TABLE 5.6: PIPELINE INVESTMENT BREAKDOWN PER TYPE OF PROJECT

Estimated budget (€m)	2010	2011	2012	2014	2016	Total
Pipeline mix	1,200					1,200
Pipeline offshore	6,000	450	500		2,500	9,450
Pipeline onshore			450	8,200		8,650
Total	7,200	450	950	8,200	2,500	19,300

Source(s): Energy Infrastructure Costs and Investments between 1996 and 2013(medium-term) and further to 2023 (long-term) on the Trans-EuropeanEnergy Network and its Connection to Neighbouring Regions withemphasis on investments on renewable energy sources and their integration into the Trans-European energy networks, including anInventory of the Technical Status of the European Energy-Network for the; Year 2003; Contract n. TREN/04/ADM/S07.38533/ETU/B2-CESI; Issue Date: October 2005; Prepared by: CESI spa (Centro ElettrotecnicoSperimentaleItaliano) – Italy, IIT (Instituto de InvestigaciónTecnológica) – Spain, ME (MercadosEnergeticos) – Spain, RAMBØLL A/S – Denmark; October 2005. Various sources including projects presentations and web sites www.nabucco-pipeline.com, www.nord-stream.com, www.igi-poseidon.com; own calculation.

TABLE 5.7: PIPELINE INVESTMENT BREAKDOWN BY COUNTRY, €m

	Austria	Estonia	Germany	Greece	Italy	Poland	Romania	Total
Algeria					1,200			1,200
Finland		100						100
Georgia							2,500	2,500
Greece					500			500
Lithuania						300		300
Norway						350		350
Romania	7,900							7,900
Russia			6,000					6,000
Turkey				450				450
Total	7,900	100	6,000	450	1,700	650	2,500	19,300

Source(s): Energy Infrastructure Costs and Investments between 1996 and 2013(medium-term) and further to 2023 (long-term) on the Trans-EuropeanEnergy Network and its Connection to Neighbouring Regions withemphasis on investments on renewable energy sources and their integration into the Trans-European energy networks, including anInventory of the Technical Status of the European Energy-Network for the; Year 2003; Contract n. TREN/04/ADM/S07.38533/ETU/B2-CESI; Issue Date: October 2005; Prepared by: CESI spa (Centro ElettrotecnicoSperimentaleItaliano) – Italy, IIT (Instituto de InvestigaciónTecnológica) – Spain, ME (MercadosEnergeticos) – Spain, RAMBØLL A/S – Denmark; October 2005. Various sources including projects presentations and web sites www.nabucco-pipeline.com, www.nord-stream.com, www.igi-poseidon.com; own calculation.

We stress the fact that these figures are regarded as minimal. In particular they do not include the expenses that have already been incurred for ongoing projects, or costs for upgrades that address specifically the improvement of national grids. Arbitration has been also carried out to eliminate possible overlaps between projects which are either potentially competitive or still subject to implementation uncertainties[41].

Due to the nature of international gas markets and a trend in the EU towards importing natural gas, several of the projects under review are located outside the EU27 territory. This is the case for the Galsi pipeline, the Nabucco pipeline (at least on part of its total length) and the White Stream pipeline. It should be stressed that the two latter projects have often been presented as two alternative options. However, given the political scale and their impact, they are included in the table above as complementary projects. A final but important issue is that various projects identified on the list are currently under implementation.

From the tables the following can be concluded:

- the completion of important projects and corresponding disbursements is spread at least over the period 2010-2015
- offshore and onshore projects are rather balanced in terms of estimated budgets but most of the additional capacity comes from offshore projects[42]
- the main corridors concerned by the budget allocation are, in turn:
  - Russia-Germany
  - Romania-Austria
  - Georgia-Romania

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[41] E.g. the South Stream project.

[42] This is due to the relative lengths, and therefore costs, of the proposed pipelines.

The investment results in additional capacity of 152 bm^3/year (see Chapter 4 for further details).

Recent network investment in the EU27

Available data on the current gas network investment within the EU27 member states are analysed in Table 5.8. Although these data do not include all development related investment (which we consider in the sections below), they indicate that the bulk of the funding was absorbed by onshore pipelines, although much of this is accounted for by a single project. Note that most of these developments are either completed or are near completion, in contrast to the longer-term nature of the pipelines projects described in the previous section.

TABLE 5.8: PROJECTS UNDER DEVELOPMENT IN THE EU27: PIPELINES

Estimated cost (€m)	2006	2008	2009	2010	Total
Compression stations		34			34
Pipeline offshore		539		300	839
Pipeline onshore	32	100	40	6,066	6,238
Total	32	673	40	6,366	7,111

Source(s): Commission staff working document; annex to the report from the commission to the European parliament, the council, the economic and social committee and the committee of the regions on the implementation of the guidelines for trans-European energy networks in the period 2002 –2004; pursuant to article 11 of decision 1229/2003/EC; {com(2006) 443 final}; 7.8.2006.

TABLE 5.9: PROJECTS UNDER DEVELOPMENT IN THE EU27, €m

Estimated cost (€m)	AT	ES	GR	IT	SB	SE	SE, NO	SK	TR	Total
AT	250								4,600	4,850
BG					100					100
DE						300				300
DK							500			500
DZ				539						539
ES		332								332
GR			66	966						1,032
IT				1,961						1,961
SK								40		40
Total	250	332	66	3,466	100	300	500	40	4,600	9,654

Note(s): DZ is Algeria, SB is Serbia, TR is Turkey.
Source(s): Commission staff working document; annex to the report from the commission to the European parliament, the council, the economic and social committee and the committee of the regions on the implementation of the guidelines for trans-European energy networks in the period 2002 –2004; pursuant to article 11 of decision 1229/2003/EC; {com(2006) 443 final}; 7.8.2006.

Geographical breakdown

An allocation of the corresponding budget between the countries in which investment is located is presented in Table 5.9. In addition to investment in compression stations and pipelines, these figures also include investment in LNG terminals and in storage (see Tables 5.10 and 5.11). The total investment figures in Tables 5.8, 5.10 and 5.11 sum to the total in Table 5.9.

The rows indicate the country marked as 'A' in the European Commission document and the column titles B; we are not making judgements on direction or financing of them.

LNG terminals

Capital expenditures on LNG terminals can vary greatly depending on site-specific factors, neighbouring facilities (especially with regard to civil engineering works) and exchange rates. This explains the large variance shown in Appendix VII, Table 7.7.6.

The detail of available data on investments under development in the field of LNG regasification terminals is presented in Table 5.10. Most of the investments address historical outlays. The available data are somewhat limited which must be considered when interpreting the figures.

TABLE 5.10: PROJECTS UNDER DEVELOPMENT IN EU27: LNG

Estimated cost (€m)	2006	2009	2010	Total
LNG terminal	1,381	152	580	2,113

Source(s): Commission staff working document; annex to the report from the commission to the European parliament, the council, the economic and social committee and the committee of the regions on the implementation of the guidelines for trans-European energy networks in the period 2002 –2004; pursuant to article 11 of decision 1229/2003/EC; {com(2006) 443 final}; 7.8.2006.

Storage capacities

Available data on the projects under development in the field of storage capacities are summarised below (Table 5.11). Again there are limitations due to the available data; however, it should be noted that there is one project that is not expected to be complete until 2013.

TABLE 5.11: PROJECTS UNDER DEVELOPMENT IN EU27: STORAGE

Estimated cost (€m)	2007	2013	Total
Underground storage	250	180	430

Source(s): Commission staff working document; annex to the report from the commission to the European parliament, the council, the economic and social committee and the committee of the regions on the implementation of the guidelines for trans-European energy networks in the period 2002 –2004; pursuant to article 11 of decision 1229/2003/EC; {com(2006) 443 final}; 7.8.2006.

Storage capacity potential is largely determined by geological factors. Taking into consideration the largest potential provided by depleted fields, most foreseeable developments should be located in the following regions (see Appendix VII, figures 6.5.1 and6.5.2.):

- North Sea: namely the Netherlands and United Kingdom
- Baltic Sea: Latvia
- eastern countries: Romania, tentatively east Slovakia and south east Poland (as long as identified potential storage sites located in the western part of Ukraine are accessible from these regions)

Even if Ukraine is unable to provide storage facilities directly to the EU, it may provide promising storage options along important import supply routes to Europe.

Various possible storage capacities are located in countries for which the infrastructure has not been developed yet, or which are limited in terms of other storage types such as aquifers, or salt cavities.

LNG terminals will also provide valuable help in the field of gas storage due to their complementary location e.g. in Spain, even if their total capacities are far below the potential offered by underground options. For this reason they are mostly associated to peak shaving purposes.

Reverse flows

Table 5.12 presents the number of reverse flow projects under consideration. They are concentrated in the short term: ie 2010 and 2011.This is explained by the size of the projects as well as by the impact of interoperability concern after the recent Russian-Ukrainian gas supply crisis. The short time horizon also explains the reason for which the visibility of the projects under implementation or under consideration is better than for the other investment projects considered above.

TABLE 5.12: NUMBER OF REVERSE FLOW PROJECTS UNDER CONSIDERATION

	2010	**2011**	**2012**	**2013**	**2015**	**N/A**	**Total**
Engineering	2	1			1	1	5
Feasibility				2		4	6
Implementation	5	2	2	1	1		11
In preparation	1	1	2				4
N/A						3	3
Planned		4				1	5
Ready for implementation	6						6
Under decision	1	4		1			6
Total	15	12	4	4	2	9	46

Source(s): GTE; Reverse Flow Study, Technical solutions, 21 July 2009.

Table 5.13 presents the equivalent figures in terms of expected investment costs. This highlights the relative project maturity. Contrary to what has been described for the number of involved projects, capital expenditures are spread over a longer period. This suggests that small short-term projects have been or are already implemented while the implementation of long-term projects will take more time.

TABLE 5.13: CAPEX OF REVERSE FLOW PROJECTS UNDER CONSIDERATION

CAPEX (€m)	2010	2011	2012	2013	2015	N/A	Total
Engineering	5	4			76	106	191
Feasibility				450		65	515
Implementation	44	115	508				668
In preparation	4	9	20				33
N/A						25	25
Planned		17				2	19
Ready for implementation	11						11
Under decision	2	14		130			145
Total	66	159	528	580	76	198	1,608

Source(s): GTE; Reverse Flow Study, Technical solutions, 21 July 2009. Own calculation.

EEPR impact

In the context of the recent economic crisis, the European Commission launched a financial package dedicated to the support of investments in the gas and electricity sectors.

In terms of maximum EU contribution, the gas sector was awarded €1.380 bn broken down as follows[43]:

Interconnectors& gas storages :	€1.3bn
Reverse flow projects:	€0.08 bn

The co-financing is limited to 50% of the projects' eligible costs but this maximum amount is not always mobilised. Therefore, we could reasonably anticipate that, because of the private leverage, the potential impact would be in line with a range of €2.76 – €5.52 bn[44].

The subsidies made available are expected to be spent over a period of 18 months.

Based on available information, various projects in the EEPR package are already included in the list of projects we have reviewed. However, many discrepancies are also observed. This can be explained by two main factors:

- the fact that the disbursement scheme is aimed at improving short-run economic recovery
- the dispersion of grants over various Member States instead of priority corridors

Comparing supply with demand

The PRIMES 2010 reference case shows a small increase in net imports to the EU by 2020 (and again to 2030) on the assumption that the 2020 policy targets are met. However, if the targets are not met the requirement for additional import capacity will be higher, and higher still if there is faster economic growth post-recession.

The published 2007 projections from the PRIMES model could therefore be considered a maximum demand; they show an increase in demand of 106 bcm/yr in 2020 (91 Mtoe/yr) and 151 bcm in 2030 (130 Mtoe/yr; see Section 4.2).

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[43] Economic Recovery: Second batch of €4 bn package goes to 43 pipeline and electricity projects, IP/10/231, Brussels, 4 March 2010.

[44] 'Eligible costs' do not cover in practice the total investments.

Table 5.14 summarises the measures to increase the supply of gas to the EU. The figures in Table 5.14 are derived from Table 5.6 but exclude the pipelines that are internal to the EU (this is discussed separately in Section 5.7).

TABLE 5.14: GAS PIPELINE PROJECTS PLANNED BEFORE 2020

Project name	**Gas origin**	**Location/ entry point in EU**	**Entry point in EU**	**Capacity (bcm/yr)**	**Load factor**	**Work capacity (bcm/yr)**	**Cumulated work capacity (bcm/yr)**	**Starting operation (estimated)**	**Estimated budget (€m)**
Galsi	Algeria	Italy	Italy	8	0.8	6	6	2010	1,200
Nord Stream	Russia	Germany	Germany	55	0.8	44	50	2010	6,000
Baltic Pipe	Norway	Poland	Poland	3	0.8	2	53	2011	350
Baltic Connector	Russia	Finland	Estonia	2	0.8	2	54	2011	100
ITGI	Caspian	Greece	Italy	8	0.8	6	61	2012	950
Nabucco	Caspian	Bulgaria	Austria	31	0.8	25	86	2014	7,900
White stream	Caspian	Romania	Romania	32	0.8	26	111	2016	2,500

Source(s): Energy Infrastructure Costs and Investments between 1996 and 2013(medium-term) and further to 2023 (long-term) on the Trans-EuropeanEnergy Network and its Connection to Neighbouring Regions with emphasis on investments on renewable energy sources and their integration into the Trans-European energy networks, including an Inventory of the Technical Status of the European Energy-Network for the; Year 2003; Contract n. TREN/04/ADM/S07.38533/ETU/B2-CESI; Issue Date: October 2005; Prepared by: CESI spa (Centro ElettrotecnicoSperimentaleItaliano) – Italy, IIT (Instituto de InvestigaciónTecnológica) – Spain, ME (MercadosEnergeticos) – Spain, RAMBØLL A/S – Denmark; October 2005; Various sources including projects presentations and web sites www.nabucco-pipeline.com, www.nord-stream.com, www.igi-poseidon.com; own calculation.

The transmission capacity offered by the above mentioned pipelines will generate a potential increase of 111 bcm/yr (96 Mtoe; assuming a load factor of 80%), which exceeds the highest projections of demand from the PRIMES model for 2020. However, the expected increases in supply will not cover the anticipated additional flow required to meet demand in 2030; a deficit of 45 bcm/yr (39 Mtoe/yr) is predicted by that date.

Our assumption is that load factors for existing infrastructure remain the same as the most recent year of data[45]. Still, based on the same sources, the estimated cost for expanding capacities through the construction of new pipelines would amount to €19,000m by 2020 (the sum of the estimated budgets in Table 5.14).

Further additional capacity required

Sources such as ENTSOG suggest that the remaining demand in 2030 will be provided by LNG regasification terminals. With a load factor limited to 60% assumed (see Chapter 4), the EU would require an increase in the region of the equivalent of 8 new units of 10 bcm (6.9-8.6 Mtoe) of max input capacity (and up to ten if the average input capacity is lower).

A paper issued by the Energy Research Centre of the Netherlands provides estimates in the field of regasification for a terminal, including 240,000 m^3 of storage (3 tanks of 80,000 m^3), for a total capital investment of 320 million US$[46].

These figures seem low when compared to those reported by other sources for the range of estimates available for the development of new LNG terminals. The most recent data suggest that CAPEX averages €500m (Appendix VII; Table

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[45] Estimates on the load factor achieved are not available for the most recent years. Therefore, this hypothesis may be regarded as conservative.

[46] www.ecn.nl

7.7.6).Thispreliminary estimation suggests that the corresponding range of investments for the 8-10 additional units would reach €4,000m.

This means that the total investment required to meet anticipated demand for natural gas in 2030 is €23,000m, including both pipelines (€19,000m) and LNG terminals (€4,000m).

Storage and reverse flow infrastructure

Storage and reverse flow-related investment should not be included in these preliminary estimates and should be accounted for separately. There are two main reasons for this:

- as regards the two types of infrastructure, the storage is related to the security, the reliability and the interoperability of the networks
- on average and over a long period, storage and reverse flow infrastructure do not amend the supply capacities except in the case of peak shaving of shift between supply routes

According to the figures quoted earlier in this chapter, the total corresponding investment would reach €2,000m for both storage and reverse flows, which is in line with 12% of the capital expenditures (€23,000m) foreseen for pipelines and LNG terminals.

These figures bring the total estimate for required investment in gas infrastructure to €25,000m.

The reported figures do not include investment for renewal or upgrading of existing infrastructures. They also do not include the network upgrades required at national level for reinforcing local transmission capacities.

Time schedule

We distinguish whenever possible the capital expenditure profile on the basis of the type of infrastructure. We must also consider the uncertainty around our estimates.

Pipelines

Most of the projects under consideration are currently in the implementation phase, with some of them near completion. Therefore, they should be operating before 2020. On this basis, we have a rather good visibility up until 2020.

In the long run, the situation is less clear. The development of new pipelines after 2020 will be directly impacted by demand evolution as well as by the export potential and relative competitiveness of foreign deposits.

Another aspect relates to the political instability that may characterise some export countries or transit corridors. For example, Iraq is likely to play an increasing role by 2020 if the political and economic outlook evolves favourably. In the longer run, Iran could also emerge as a main exporter. If these scenarios are confirmed, we may reasonably anticipate the development of new routes via the south-eastern regions of the Mediterranean Basin.

LNG terminals

As far as terminals are concerned, investment planning will probably cover a longer period. There are three main reasons for this:

- First, LNG supplies are still characterised by a certain lack of competitiveness for short to medium distance routes. The competitive advantage appears to be for longer routes (Appendix VII, Figure 7.8.2). The highly probable eventuality of a gradual increase of NG prices in the long run tends to reinforce, other things being equal, the competitiveness of the LNG chain.

- Second, the maturity level of projects is variable. Many projects are currently under consideration (Appendix VII; Figure 7.6.7.a); we are still far upstream in the decision process for many of the projects, with just a small number of exceptions (Appendix VII; Table 7.7.6).
- The third and final reason is driven from the expectations in terms of market development at EU27 level, especially with regard to the search of alternative routes and arbitration.

Storage The investment planning in storage capacities is unclear.

As a large part of the storage potential is provided by depleted fields, we can anticipate that, at the 2030 horizon, new deposit sites will appear with the gradual decay of EU27 production. This needs to be considered as a factor affecting longer-term storage capacity decisions.

The viability of other storage sites will also depend on access to the network, from which they can be far away. Opportunities could also arise from the development of these networks, namely at national level.

Reverse flows As already mentioned, most reverse flow projects are expected to be realized before 2015.

Each of them can usually be implemented on a short-term basis. This is opposite to the time frame required for main pipelines and gas terminals, which are usually implemented over a period of at least five years.

Location This section summarises where the investments are likely to take place, in particular for the LNG terminals required to meet demands in 2030.

Pipelines The location of the projects under consideration or planned is already known (see paragraph ‘gas transportation corridors’ in section 4.3 and Figure 4.1). This addresses at least the medium-term development (2020).

LNG terminals Recent studies indicate that the most promising locations for new LNG terminals are, in turn:

- Italy: Porto Empedocle, Tarento, Trieste, Livorno, Monfalcone, Priolo, Gioia Tauro, San Ferdinando
- Netherlands: Lion Gas, Gate LNG
- France: Le Verdon, Dunkirk
- Ireland: Shannon
- Germany: Wilhemshaven
- Poland: Swioujscie
- Spain: El Murel
- Croatia: Krk
- Cyprus: Vassiliko

Other projects have been or are envisaged such as:

- Greece: Crete[47]
- Croatia: Ploce[48]

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[47] STRATEGIC STUDY OF NATURAL GAS SUPPLY TO THE ISLAND OF CRETE FOR POWER GENERATION; Executive Summary to the Engineering and Economic Assessment; Prepared for the Regulatory Authority by: David Haynes, Carol Humphreys, Paul Martin and Nick Stranks; Advantica, November 2004.

The total number of sites under consideration exceeds the total amount of required LNG projects estimated above at the 2030 horizon, unless the projects under consideration end up with smaller capacities than expected. However, this option remains rather unlikely due to the loss of economies of scale at the level of the LNG terminal itself, as well as for connecting pipelines.

New technologies

No reference has been found in the existing studies on the possible development of ships equipped with their own regasification devices. This recent technology cannot at present compete with classical onshore regasification plants that benefit from economies of scale, higher capacities and, eventually, of large storage capacities. However, this technology can be promising either for isolated markets (such as islands) or in a transitory phase.

The same remark concerns the Compressed Natural Gas (CNG) projects. This technology, like ships equipped with regasification technology, is only likely to find possible market niches in isolated markets or for markets whose infrastructure is in a transitional phase. However, available data show the CNG competitiveness vis-à-vis classical LNG chain corresponds in practice to short transportation[49]. Furthermore, the CNG process is not compatible with large off-take capacities.

Storage

At present, storage potential is offered by the few regions mentioned previously (the Netherlands and UK, Latvia, Romania and possibly Slovakia and Poland). Some of them could match specific requirements, such as in the UK, which became a net importer in the early 2000’s and suffered from a lack of storage capacity with regard to its market size, particularly in comparison with neighbouring countries. It seems possible that part of the development of storage facilities will take place over the period 2010-2020 to compensate for reductions in domestic production.

Reverse flow projects

A list of identified projects is provided in Appendix VII (Table 7.6.9).

5.5 Additional investment needs for gas interconnections within Europe

Introduction

In estimating the investment costs of new cross-border infrastructure, we cannot ignore connections within member states, as this could comprise a significant share of the total expenditure covering sub-regional transportation capacities as well as reinforcements required for connecting national grids to international interconnectors. However, it also must be noted that there is considerable uncertainty over the number and scale of the projects that are likely to go ahead, for example due to the political factors involved.

This part of the exercise was therefore carried out separately to the analysis in previous sections. The description of the projects should not be viewed as a prediction of future developments but a scenario of one possible outcome, based on a fairly arbitrary set of connections that could improve overall security of supply across Europe. The associated costs are determined either by previously quoted estimates or by a simple calculation based on approximate length and average unit costs; they are subject to the same degree of uncertainty.

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[48] NATURAL GAS SUPPLY ALTERNATIVES FOR SOUTH EAST AND CENTRAL EUROPE; Naim H. Afgan, Academy of Science and Art of Bosnia and Herzegovina, Power point presentation; Balkan Political Club, Sarajevo, May 5-7, 2006

[49] CNG: A Competitive Technology to LNG for the Transport of Natural Gas; AsimDeshpande and Michael J. Economides, Power point presentation.

Scope

We consider the transportation from western EU countries to central EU countries of natural gas mainly imported from LNG terminals:

- Entry points: Spain (North): e.g. Oviedo, Gijon, Bilbao and Barcelona
- Exit point: South Germany (Ulm)

This could potentially lead to Spanish LNG facilities being used as an alternative source of natural gas for central Europe.

The basic methodology

There are two options for this development to take place. One is to expand on existing national infrastructure with additional connectors, while the other is to build a new pipeline. The second option was chosen as the alternative would require a load flow simulation and analysis of bottlenecks[50].

It is assumed that the imports of natural gas come from existing LNG facilities and that no further infrastructure improvements (including connections between the new pipeline and existing grids structures) are required. The terminals are:

- Bilbao (Gaviota): 7 bm³/year capacity (current), 12.3 bm³/year (by 2011); 800,000 m³N/h send out capacity (current), 1,400,000 m³N/h (by 2011)
- El Ferrol: 7 bm³/year capacity (current), 10.5 bm³/year (future); 800,000 m³N/h send out capacity (current), 1,200,000 m³N/h (future)
- Gijon (Musel): 7 bm³/year capacity (by 2011), 10.5 bm³/year (future); 800,000 m³N/h send out capacity (by 2011), 1,200,000 m³N/h (future)
- Barcelona: 17 bm³/year capacity (2009); 1,950,000 m³N/h send out capacity (2009)

Distances involved

The suggested route is Oviedo-Bilbao-Barcelona-Ulm (see Figure 5.1). This implies minimum distances of:

- Oviedo-Bilbao: 289 km
- Bilbao-Barcelona: 610 km
- Barcelona-Ulm: 1,343 km

The minimum distance is therefore 2,242 km.

Cost assumptions

Based on a sample of onshore projects, it is assumed that the average cost is between €1.5m and €2.5m per kilometre.

Implied costs

Given all of these assumptions, the estimated total investment cost for projects within the EU is between €3.4 bn and €5.6bn in 2020. This is additional to the estimated sum for external-EU projects in the gas sector estimated in the previous sections so, taking the midpoint in the range, the total investment costs for the sector are estimated at €29.5 bn. This is the value that we use in the modelling scenarios (see Chapter 6).

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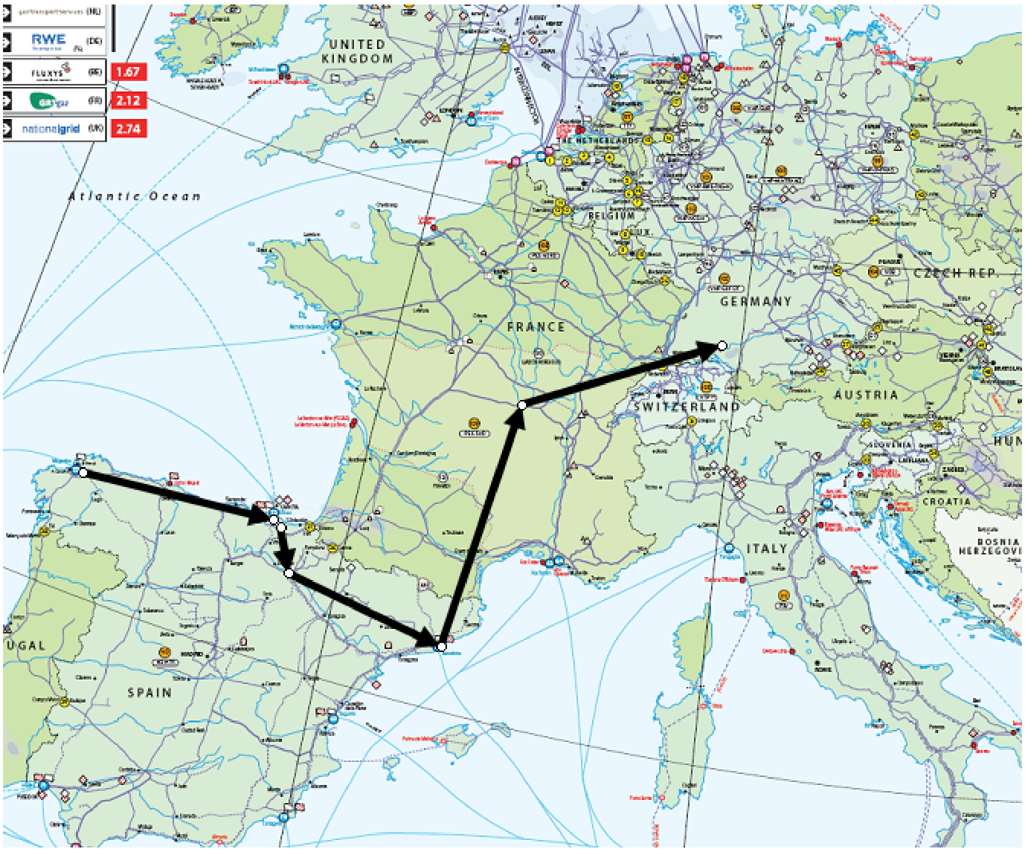
[50] Some preliminary studies have been carried out in this respect. For example, the GTE report emphasizes the possible investments in the EU countries (ref. Reverse Flow Study TF Technical Solutions, GTE, 21 July 2009). Most of the analyzed investments are located in Central Europe. The study does not cover the results of the load flow analysis.

Figure 5.1: Location of the Pipeline



6 Definition of Investment Base Case and Scenarios

6.1 Introduction

This chapter describes the base case and the scenarios that were modelled with the E3ME model. Section 6.2 briefly discusses the use of the base case in the modelling, including the calibration procedures that were used.

Types of scenarios

The scenarios are then split into three groups:

- scenarios specific to the electricity sector
- scenarios specific to the gas sector
- combined scenarios

These are summarised in Table 6.1 and described in more detail in Sections 6.3 to 6.5. The scenarios for the electricity sector are consistent between the modelling using E3ME and the KEMA network model (except for the public funding option). The other scenarios are assessed only in E3ME.

TABLE 6.1: SCENARIODEFINITIONS

Name	Investment (2008 prices)	Funding Mechanism	Comments
Electricity Scenarios			
ES1	€78.5 bn	Private	
ES2	€169.4bn	Private	
ES3	€78.5 bn	5% Public	
ES4	€169.4bn	5% Public	
Gas Scenarios			
GS1	€29.5 bn	Private	
GS2	€29.5 bn	Private	Fall in gas prices due to greater supply from outside the EU
GS3	€29.5 bn	5% Public	
GS4	€29.5 bn	5% Public	Fall in gas prices due to greater supply from outside the EU
GS5	0	N/A	Storage compensates for loss of supply
GS6	0	N/A	Loss of supply to industry
GS7	0	N/A	Loss of supply to whole economy
Combined Scenarios			
CS1	€89bn	€155m public	
CS2	€122bn	€15 bn public	
CS3	€118bn	€155m public	

TABLE 6.1: SCENARIODEFINITIONS

Name	Investment (2008 prices)	Funding Mechanism	Comments
CS4	€142 bn	€155m public	
CS5	€164bn	€15 bn public	
CS6	€202 bn	€15 bn public	

All the scenarios are run for the EU27 Member States, plus Norway and Switzerland, with a time horizon up to 2030. However, the majority of results in Chapter 7 are repeated for 2020, reflecting the proposed investment profiles.

6.2 The base case

EU Energy Trends to 2030: Update 2009

In modelling exercises at the European level, it is common to use the projections published in *EU Energy Trends to 2030: Update 2009*[51] as a base case. These figures are regularly updated and mainly consist of outputs from the PRIMES model. In summary they contain:

- economic and demographic assumptions
- energy price assumptions
- primary and final energy demands, by sector and by fuel type
- additional detail on the power generation sector

The figures are produced from a single modelling exercise, giving a level of consistency between the different outputs. This is essential for use in further modelling exercises as the build-up of imbalances can lead to bias in the results.

The base case that was used for the scenarios in this project is the PRIMES 2010 reference case, which was also one of the main inputs to the analysis in Chapters 3-5.In this set of projections, it is assumed that the EU's 20% targets for greenhouse gas emission reduction and share of renewable power are met.

While the energy demands and methods of electricity generation are inputs to both models used in the project, E3ME also requires the economic projections as part of the base case solution. Some further processing of inputs, including conversion to the model's classifications and estimation of other economic indicators is required; this is described in detail in the intermediate report for the project.

All figures are converted from five-yearly intervals to annual time series using a basic interpolation method.

6.3 Scenarios of the electricity sector

The scenarios in the electricity sector are common to the modelling by KEMA and E3ME. The KEMA model provides an assessment of investment needs in the scenarios (see Chapter 3) while E3ME adds an economic assessment (Chapter 7).

The main scenarios are:

- Base case (see Section 6.2)

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[51] EU Energy Trends to 2030: Update 2009 (baseline 2009 and reference scenario 2009). A detailed description of these scenarios and their assumptions is available at http://ec.europa.eu/energy/studies/index_en.htm.

- ES1 – Additional investment[52] based on PRIMES 2010 reference case
- ES2 – Additional investment in a case with higher renewables penetration[53]
- ES3 & ES4 – Public funding for these investments

Treatment of investment

The same underlying assumptions are generally applied for both the electricity and gas scenarios (see Section 6.4). In particular, investments in cross-border interconnections are split 50/50 between start and end country (for electricity almost all of the investment is within the EU, but this is not the case for gas pipelines, see below) and the investment is spread equally over the period 2011-20 and 2021-30.

The increase in investment in E3ME is defined as that related to the ENTSO-E Ten Year Network Development Plan (TYNDP) plus the additional requirements, in both off-shore integration investment and interconnectors that were identified by the KEMA model.In ES1 this comes to a total of €60.5 bn based on the PRIMES reference scenario by 2020 and €78.5 bn by 2030 (see Table 6.1).For ES3 the €60.5 bn of investment in 2020 is added to the additional offshore integration and interconnection investment projected in the High RES scenario between 2020 and 2030, giving a total of €169.4 bn.

It is assumed that the investment is made by electricity companies. However, no direct knock-on effect on prices is modelled in these scenarios, as the focus is on cross-border interconnections, where the effects are likely to be subject to too much uncertainty given changes in supplies[54].

In ES3 and ES4, a share of the investment (5%) comes from public finances. This is funded by a very small increase in direct tax rates so that there is overall direct revenue neutrality in the scenario.

6.4 Scenarios of the gas sector

The scenarios for the gas sector are:

- Base case (described above)
- GS1 – Investment scenario
- GS2 – Investment scenario with secondary impact on gas prices
- GS3 & GS4 – Investment scenarios (1 and 2) with public funding
- GS5, GS6 & GS7 – Crisis scenarios

Apart from the base case, seven separate model runs were carried out. These are described in turn below.

Treatment of investment

The level of additional investment was determined by the analysis in Sections 5.5 (additional capacity into the EU) and 5.6 (additional capacity within the EU).The total investment is €29.5 bn over the period 2011-30, most of which is met by 2020.

Assumptions on where the investment is made

For the pipelines in Table 5.15 it was assumed that half of the physical investment is made within the EU, and half outside the EU. Where the pipeline lies in more than one EU country, the share of investment is split equally. The spending on LNG ports (€4 bn) was shared equally between the nine countries that were mentioned as possibilities

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[52] In the KEMA modelling this requires a separate assessment for 2020 and 2030 but this constitutes a single run in E3ME.

[53] It should be noted that in this scenario the model results will provide an assessment of the additional investment required for interconnectors and back-up, not the investment to build the new renewable power generation capacities.

[54] In reality the additional cross-border flows will be at peak times and may be in both directions, so it is difficult to estimate a change in an average annual price.

and the additional spending (€2 bn) was shared out in line with the other physical investments.

Although it is noted that these assumptions are arbitrary in nature, given the levels of uncertainty surrounding the timing and location of the investments they are not unreasonable. Furthermore, they do not introduce any bias in the analysis.

Assumptions on the timing of the investment

In a similar manner as the electricity scenarios, the investment spending is shared out evenly over ten-year periods. For pipelines this is assumed to fall into 2011-20 and for LNG ports this period is 2021-30. The additional spending is shared out as a fixed ratio to the infrastructure spending.

Treatment of gas prices

In GS1 it is assumed that the investment is made by private companies but does not have an impact on wholesale gas prices within the EU. In the GS2, the increase in supply from outside the EU could lead to lower prices and an increase in demand. The scale of the price changes is dependent on the tightness of the market in the base case, which we are not in a position to judge, but it is not inconceivable that there could be a reduction in European prices towards international wholesale rates.

We enter a reduction of 10% by 2020 to give an indication of impacts. Although E3ME is a non-linear model, its results tend to be fairly linear at the aggregate level, so it can be reasonably inferred that a 20% reduction would have double the effect.

Following from Table 5.15, the additional capacity (using the assumption of 80% utilisation and a conversion rate of 1.16 from bcm to mtoe) is 95.7 mtoe pa by 2020, with a further 62 mtoe in 2030.It is assumed that prices decrease gradually over time (compared to the base case) as the new interconnection capacity comes on stream.

Financing the investment

In GS3 and GS4, it is assumed that 5% of the additional investment is paid from public funds. In order to maintain revenue neutrality, a very small increase in direct taxes across the EU is imposed to compensate. The rest of the financing is made privately but is assumed not to affect gas prices.

The crisis scenarios

The scenarios above outline the economic costs and benefits of making the additional infrastructure in the gas sector, but do not really address the issue of energy security. GS5-GS7 approach the issue from the opposite perspective of a lack of investment in new connections being followed by a sudden loss of supply due to disruption in traditional supply contracts/routes.

It should be noted that the assumptions that underlie these scenarios are highly stylised in nature with many simplifications made along the way (particularly relating a sudden supply shock to annual outcomes); as such the results should be viewed as indicative of the scale of possible economic outcomes, rather than an attempt at quantifying likely impacts.

The scenarios are based on a 100% loss of supply from the Ukraine for two weeks. We have identified three separate outcomes, based on the degree of domestic storage that can compensate loss of imports:

- GS5 – Domestic storage is able to compensate for the loss of supply so the effects are minor. Gas prices increase slightly over the year to reduce demand and replenish stocks but there are no cases of supplies running out.
- GS6 – Although domestic storage is able to provide gas supplies to households and electricity generation (apart from where gas can be substituted by other fuels),

industrial users are forced to halt production over the two week period and there is a loss of economic output in these sectors.

- GS7 – All users, including households and power generation, face a two-week period with no access to gas supplies. Although the primary outcomes of this scenario are social rather than economic, there will be a further loss of economic activity.

Countries' exposures to Ukraine

The impacts on Member States will vary according to their level of exposure. For example, many EU members will be able to supply gas to households from other sources. Table 6.2 provides the assumptions on loss of supply to each country, based on rough estimates from 2010 provided by DG Energy. We assume that these estimates remain the same in 2020, although we do take into account the expected change in electricity generation mix (from PRIMES results).

It is assumed that countries prioritise by cutting supplies to consumers of gas in the following order:

- electricity generation where an alternative fuel (coal or oil) can be used[55]
- industrial use[56]
- households and remaining electricity generation

TABLE 6.2: POTENTIAL REDUCTION IN GAS SUPPLY

Country	Reduction in gas supply %	Country	Reduction in gas supply %
Belgium	0	UK	0
Denmark	0	Czech Republic	40
Germany	15	Estonia	0
Greece	70	Cyprus	0
Spain	0	Latvia	0
France	10	Lithuania	0
Ireland	0	Hungary	60
Italy	20	Malta	0
Luxembourg	0	Poland	25
Netherlands	0	Slovenia	30
Austria	25	Slovakia	70
Portugal	0	Bulgaria	60
Finland	0	Romania	15
Sweden	0		

Source(s): European Commission (DG Energy).

6.5 Combined scenarios

Table 6.3 defines the scenarios that were assessed. The inputs are defined in terms of investment (in electricity infrastructure, gas infrastructure and CCS) and share of EU

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[55] Due to the short nature of the shock we assume that electricity prices remain unchanged.

[56] Although we do not know the share of manufacturing that is dependent on gas as an input to the production process we assume a 50% share. So, for example, a 50% loss of gas supply to industry would imply a 25% loss of production.

financing. The shares of the investment that are not met by EU financing are assumed to be paid for privately, although without a knock-on effect on energy prices[57].

In an annual model such as E3ME it is also important to note the timing of the investment. The general assumption is that the investments are split evenly across the ten-year period 2011-20, although in some cases it is possible to make a further split between 2011-15 and 2016-20.For example, the total level of investment in CS6 is higher than in CS5, but the impacts in 2020 are greater in CS5, as more investment falls into that period.

TABLE 6.3: INVESTMENT DETAILS OF COMBINED SCENARIOS

Scen.	Electricity	Gas	CCS	EU Financing
CS1	€45 bn	€44 bn		€155m (60% elec, 40% gas)
CS2	€71 bn	€51 bn		€15 bn (60% elec, 40% gas)
CS3	€68 bn	€47 bn	€2.6 bn	€155m (shared*)
CS4	€90 bn	€49 bn	€2.6 bn	€155m (shared*)
CS5	€107 bn	€54 bn	€2.6 bn	€15 bn (shared*)
CS6	€142 bn	€57 bn	€2.6 bn	€15 bn (shared*)

Note(s) : * The shares are 11/30 gas, 11/20 electricity, 1/12 CCS.

Investment by Member State

As E3ME is defined by member state, it is important to determine how the investment is shared out between countries (including those outside Europe) as this will have a significant impact on the modelling results at the member state level. This exercise was carried out on the following basis:

- Electricity – For standard transmission investment within a single country, the same shares as in the ENTSO-E TYNDP are used. For interconnectors and offshore investment, the shares from the KEMA model results (see Chapter 5) were used. For smart grids the investment was split according to national grid lengths (source: ENTSO-E).
- Gas – We have not attempted to link the investments to individual projects, so the investment sums were shared out according to geographical land area (source: Eurostat). This treatment is a simplification and is not meant to reflect actual data or expectations of future developments, which are subject to considerable uncertainty.
- CCS – Of the total CCS investment, approximately half falls in the UK and a further €1 bn in Germany and the Netherlands. The remaining amount is spread between Spain, Italy and Poland.

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[57] Without a detailed knowledge and designated tool it is difficult to predict the outcome of energy prices. On the one hand an increase and smoothing in supply could lead to a reduction in prices, while on the other hand the energy companies may seek to increase prices to cover investment costs. No change is therefore seen as a neutral view.

7 Macroeconomic Impact Modelling Results

7.1 Introduction

This chapter presents the results from the modelling expertise that was carried out with E3ME, split into the three sets of scenarios (electricity, gas and combined).The scenarios are described in more detail in Chapter 6.

The general structure for presentation of results is to first show the aggregate economic impacts, and then consider the results on a country-by-country and sectoral basis. This is an important part of the analysis as many of the impacts are region and sector-specific, for example depending on location of infrastructure and construction costs. Social impacts, in terms of income distribution, are also presented for each set of scenarios and the final section in this chapter briefly considers impacts on SMEs.

7.2 Results from the electricity scenarios

Scenario definitions

In this section the results from the electricity scenarios are presented. In ES1 additional investment occurs based on the PRIMES 2010 reference case. ES3 is identical to ES1, except it is assumed that 5% of the additional investment is met by public funding at the European level. In ES2 a higher degree of the additional investment is used for developing renewable energy sources between 2020 and 2030. ES4 makes the same assumptions as ES2, with the additional assumption that a 5% share of the investment comes from public finances. A small increase in direct taxes is assumed in ES3 and ES4, in order to maintain revenue neutrality. In all scenarios investments in cross-border interconnections are split 50/50 between the start and end country and the investment is spread equally over the period 2011-2020 and 2021-2030. In summary:

- ES1 – investment matching the PRIMES reference case
- ES2 – investment for higher renewables share after 2020
- ES3 – investment matching the PRIMES reference case with 5% public funding
- ES4 – investment for higher renewables with 5% public funding

As ES2 is identical to ES1 in 2020, and ES4 is identical to ES3 in 2020, the tables in this section show results for ES1 and ES3 in 2020, and for all the scenarios in 2030.

Macroeconomic impacts

In this section we present results for both 2020 and 2030, to account for the additional investment in renewables after 2020 in ES2.

Tables 7.1 and 7.2 present a summary of the macroeconomic impacts in 2020 and 2030, respectively. The first point to note is that the results are positive, albeit very small. It can be seen that in 2020 the results are almost identical for ES1 and ES2, and ES3 and ES4. The method of investment used does not therefore have much of a macroeconomic impact. Household spending is slightly lower in ES3 and ES4, due to the small increase in direct taxes that are assumed in these scenarios.

Compared to the base case, GDP rises by 0.05% in 2020 in all the scenarios. As would be expected, this is driven by increases in investment. The expected increase in GDP in the electricity scenarios is larger than that expected under the gas scenarios (see next section) because of the larger scale of investment. In 2030 a 0.01% increase in GDP is expected in ES1 and ES3, while a much larger rise of 0.10% is expected in

ES2 and ES4. This is driven by a higher level of investment required for connection of renewable sources in these scenarios up to 2030.

The investment in new electricity infrastructure will lead to a rise in economic activity in general, as demand for specific sectors' (e.g. construction and engineering) output is intensified (see below for sectoral impacts). These sectors may in turn increase employment levels and, as the results show, increases in employment are indeed expected in 2020 and 2030.

Prices rise very slightly in 2030, due to capacity constraints in certain sectors. As shown later in this section, this increase is mainly due to higher prices in sectors such as construction, mechanical engineering and other business services, all sectors that will see a direct increase in demand due to the infrastructure investments. However, the change is so small it could be viewed as zero at the macro level.

TABLE 7.1: SUMMARY OF MACROECONOMIC IMPACTS, 2020 (EU27)

	ES1	ES2	ES3	ES4
GDP	0.05	0.05	0.05	0.05
Household spending	0.02	0.02	0.01	0.01
Investment	0.17	0.17	0.17	0.17
Exports	0.03	0.03	0.03	0.03
Imports	0.03	0.03	0.03	0.03
Employment	0.03	0.03	0.02	0.02
Prices	0.01	0.01	0.01	0.01

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

TABLE 7.2: SUMMARY OF MACROECONOMIC IMPACTS, 2030 (EU27)

	ES1	ES2	ES3	ES4
GDP	0.01	0.10	0.01	0.10
Household spending	0.01	0.05	0.01	0.04
Investment	0.04	0.24	0.04	0.24
Exports	0.00	0.05	0.00	0.05
Imports	0.02	0.06	0.02	0.06
Employment	0.01	0.04	0.01	0.04
Prices	0.01	0.01	0.01	0.01

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in investment

Table 7.3 shows expected change in investment. This includes the exogenous increase in infrastructure that defines the scenarios plus secondary impacts. The results show that in most countries there is little difference in the increase in investment expected under each scenario in 2020. The difference in investment compared to the base case is by far the largest in Malta due to expensive offshore connections. Other island nations within the EU also see large increases in investment such as Cyprus (+0.81%) and the UK (+0.41%). Otherwise, the trend is that larger amounts of investment (relative to existing levels) are required in central and eastern European countries. These include Estonia, Latvia and Slovenia.

In 2030, the increases in investment in ES1 and ES3 compared to the base case are, in most cases, lower than in 2020. This is because investment in interconnections in 2030 is much lower than in 2020, or no new additional investment has occurred. While there is a greater emphasis on offshore integration investment in 2030, in ES1 and ES3 overall electricity infrastructure investment is still lower than in 2020. The exception to this rule is Germany, in which a considerably higher level of offshore integration investment is expected in 2030, bringing total investment levels higher than in 2020. Changes in investment are positive in ES2 and ES4 for 2030 and higher than in ES1 and ES3. This is due to the higher degree of investment in renewable energy infrastructure.

TABLE 7.3: IMPACT ON INVESTMENT, 2020 AND 2030

	2020		2030			
	ES1	ES3	ES1	ES2	ES3	ES4
Austria	0.04	0.04	-0.01	0.00	-0.01	0.00
Belgium	0.16	0.16	0.04	0.32	0.03	0.31
Bulgaria	0.86	0.86	-0.01	0.29	-0.01	0.29
Cyprus	0.81	0.81	0.01	0.17	0.01	0.17
Czech Republic	0.03	0.03	0.01	0.06	0.01	0.06
Denmark	0.21	0.22	0.01	0.09	0.01	0.09
Estonia	1.21	1.21	0.01	0.05	0.01	0.05
Finland	0.34	0.34	-0.04	0.01	-0.04	0.01
France	0.14	0.14	0.03	0.29	0.02	0.29
Germany	0.10	0.10	0.20	0.43	0.19	0.43
Greece	0.13	0.13	-0.02	0.00	-0.02	0.00
Hungary	0.07	0.07	0.01	0.02	0.01	0.03
Ireland	0.15	0.15	0.01	0.04	0.01	0.04
Italy	0.01	0.01	-0.02	-0.04	-0.03	-0.04
Latvia	0.97	0.97	0.59	0.62	0.59	0.62
Lithuania	0.19	0.19	0.00	0.25	-0.01	0.24
Luxembourg	0.00	0.00	0.00	0.05	0.00	0.05
Malta	41.03	41.03	0.00	1.85	0.00	1.85
Netherlands	0.62	0.62	-0.03	0.38	-0.02	0.38
Poland	0.10	0.10	-0.01	0.05	-0.01	0.05
Portugal	0.23	0.23	-0.02	0.04	-0.02	0.04
Romania	0.20	0.20	0.01	0.06	0.01	0.05
Slovakia	0.14	0.14	-0.01	-0.01	-0.01	-0.01
Slovenia	0.98	0.98	0.04	0.03	0.04	0.03
Spain	0.07	0.06	0.06	0.31	0.06	0.31
Sweden	0.11	0.10	0.01	0.13	0.02	0.13
UK	0.41	0.41	0.00	0.42	-0.01	0.42
EU27	0.17	0.17	0.04	0.24	0.04	0.24

Note(s): Figures are % difference from base case. They include the exogenous increase in investment defined in the scenarios, plus any induced secondary effects.
Source(s): E3ME, Cambridge Econometrics.

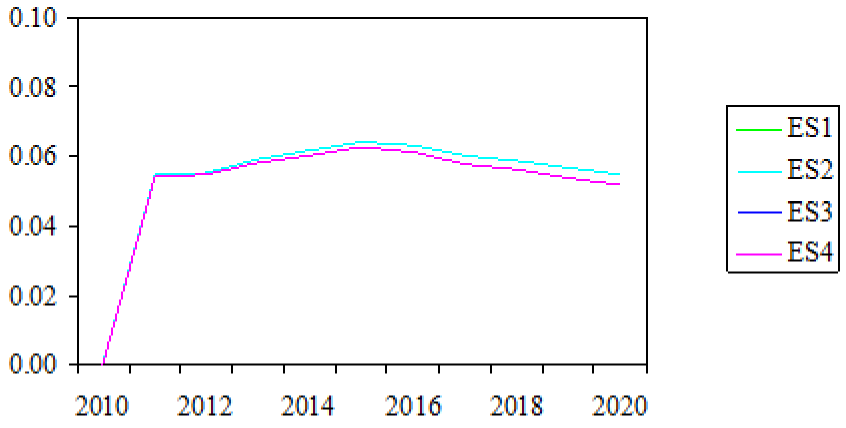
Impacts on GDP

Figure 7.1 shows how European GDP changes over time in the period up to 2020. The impact on GDP for each Member State is shown in Table 7.4. The changes in GDP are, in most cases, similar for all scenarios in 2020. The largest change in GDP is seen in Malta, where GDP is expected to increase by 3.1%. This reflects the scale of investment that is shown in Table 7.3.

Even leaving aside Malta, the gains in GDP are the highest in countries which are likely to see the largest amount of additional investment, particularly in Estonia (+0.40%), Latvia (+0.39%) and Slovenia (+0.21%).

In 2030, GDP is lower in ES1 and ES3 compared to 2020.This is due to the above-mentioned falls in investment. In some cases these falls in investment translate into negative changes in GDP compared to the base case as the dynamic effects of slowing investment lead to reductions in overall activity rates. Positive changes in GDP are, however, expected for ES2 and ES4 in the majority of Member States, as the additional investment in offshore infrastructure boosts economic activity.

FIGURE 7.1: EU27 GDP FOR EACH ELECTRICITY SCENARIO, % DIFFERENCE FROM BASE CASE



Source(s) : E3ME, Cambridge Econometrics.

TABLE 7.4: IMPACT ON GDP, 2020 AND 2030

	2020		2030			
	ES1	**ES3**	**ES1**	**ES2**	**ES3**	**ES4**
Austria	0.02	0.02	0.01	0.03	0.01	0.03
Belgium	0.07	0.06	0.05	0.17	0.04	0.17
Bulgaria	0.13	0.13	0.01	0.09	0.01	0.09
Cyprus	0.18	0.18	0.02	0.08	0.02	0.08
Czech Republic	0.07	0.07	0.02	0.10	0.01	0.10
Denmark	0.05	0.05	0.00	0.03	0.00	0.03
Estonia	0.40	0.40	0.03	0.12	0.02	0.11
Finland	0.05	0.05	0.01	0.10	0.01	0.10
France	0.09	0.09	-0.06	-0.03	-0.06	-0.03
Germany	0.03	0.03	-0.06	0.07	-0.06	0.07
Greece	0.04	0.04	0.06	0.18	0.06	0.17
Hungary	0.05	0.05	-0.01	0.03	-0.01	0.02
Ireland	0.05	0.05	0.01	0.07	0.01	0.07
Italy	0.12	0.11	-0.02	0.03	-0.03	0.03
Latvia	0.02	0.02	0.00	0.02	-0.01	0.02
Lithuania	0.39	0.38	0.32	0.40	0.32	0.39
Luxembourg	0.09	0.08	-0.01	0.12	-0.01	0.12
Malta	0.05	0.05	0.02	0.11	0.02	0.11
Netherlands	3.07	3.07	0.11	0.27	0.11	0.27
Poland	0.12	0.12	0.01	0.10	0.00	0.11
Portugal	0.05	0.05	-0.01	0.06	-0.01	0.06
Romania	0.03	0.03	-0.01	0.01	-0.01	0.01
Slovakia	0.06	0.05	0.01	0.05	0.02	0.05
Slovenia	0.07	0.07	-0.03	0.13	-0.03	0.13
Spain	0.21	0.21	0.01	0.02	0.01	0.02
Sweden	0.03	0.03	0.06	0.20	0.06	0.20
UK	0.05	0.04	0.01	0.06	0.01	0.06
EU27	0.08	0.08	0.00	0.10	0.00	0.10

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Household expenditure

Table 7.5 gives the impact on household spending broken down by Member State. In ES1 and ES2 we would expect a very small increase in household spending; although there are no direct impacts, average incomes should increase if more jobs are created in the engineering and construction sectors.

Household spending is either the same, or slightly lower in 2030 in ES3 and ES4 compared to ES1 and ES2 respectively, as the increase in direct taxes in these scenarios reduces real incomes and hence household expenditure.

The highest increases in household spending are observed in those countries in which investment is expected to be largest, such as Malta and Latvia. Multiplier effects through supply chains means that the initial increase in GDP that results from higher investment and activity in specific sectors will itself lead to more economic activity from both firms in other sectors and from households, hence the higher levels of household spending we see for many of the Member States in these scenarios.

Some reductions in household spending are observed in 2030, as investment in interconnections falls, bringing employment levels down with it (usually after a lag). This reduces real incomes and hence household spending. In most countries in ES2 and ES4, the additional investment in offshore integration projects counteracts this, and household spending increases by a small amount. Again, those countries which expect to see the largest increases in investment will see the largest impact on household spending in 2030, such as Latvia and Malta.

TABLE 7.5: IMPACT ON HOUSEHOLD SPENDING, 2020 AND 2030

	2020		2030			
	ES1	ES3	ES1	ES2	ES3	ES4
Austria	0.01	0.01	0.01	0.02	0.01	0.02
Belgium	0.08	0.07	0.12	0.32	0.11	0.30
Bulgaria	0.01	0.00	-0.01	-0.01	-0.01	-0.01
Cyprus	0.04	0.03	0.01	0.02	0.01	0.02
Czech Republic	0.01	0.00	0.02	0.02	0.02	0.02
Denmark	0.01	0.00	0.00	0.01	0.00	0.01
Estonia	0.05	0.05	0.06	0.06	0.06	0.06
Finland	0.02	0.01	0.00	0.00	0.00	0.00
France	0.01	0.00	-0.02	0.01	-0.02	0.00
Germany	0.01	0.00	0.03	0.08	0.02	0.07
Greece	0.03	0.03	-0.02	0.00	-0.02	0.00
Hungary	0.05	0.05	0.02	0.08	0.01	0.07
Ireland	0.02	0.01	0.01	0.05	0.01	0.04
Italy	0.01	0.01	0.00	0.01	0.00	0.01
Latvia	0.20	0.19	0.17	0.18	0.17	0.18
Lithuania	0.07	0.06	0.01	0.10	0.01	0.10
Luxembourg	0.02	0.02	0.02	0.02	0.02	0.02
Malta	0.35	0.35	0.14	0.16	0.14	0.16
Netherlands	0.05	0.04	0.02	0.06	0.02	0.06
Poland	0.01	0.01	0.00	0.02	0.00	0.01
Portugal	0.02	0.01	0.01	0.05	0.01	0.04
Romania	0.03	0.02	0.01	0.04	0.01	0.04
Slovakia	0.01	0.01	0.02	0.02	0.02	0.02
Slovenia	0.05	0.05	0.03	0.04	0.03	0.04
Spain	0.01	0.01	0.03	0.06	0.03	0.06
Sweden	0.02	0.01	0.01	0.04	0.01	0.04
UK	0.02	0.02	0.02	0.06	0.02	0.06
EU27	0.02	0.01	0.01	0.05	0.01	0.04

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Impact on employment

Some increase in employment will occur as a direct result of the additional investment, since demand for the services of certain sectors, such as construction and other business services, may stretch capacities.However, as a proportion of total employment, this increase will be small. Table 7.6 demonstrates that the changes in employment are expected to be very small, in the range of 0 to 0.1% for most Member States in 2020.This equates to around 19,000 additional new jobs in Europe in 2020, mainly to carry out the investment projects.The increases in employment are larger in general in central and eastern Europe where most of the additional activity takes place.

In 2030, the falls in investment in ES1 and ES3 can lead to lower levels of employment for some countries compared to 2020. ES2 and ES4 result in higher employment levels, as the additional investment continues.

TABLE 7.6: IMPACT ON EMPLOYMENT, 2020 AND 2030

	2020		2030			
	ES1	**ES3**	**ES1**	**ES2**	**ES3**	**ES4**
Austria	0.00	0.00	0.01	0.02	0.01	0.02
Belgium	0.02	0.02	0.01	0.07	0.01	0.06
Bulgaria	0.03	0.03	0.08	0.05	0.08	0.05
Cyprus	0.16	0.16	0.00	0.04	0.00	0.04
Czech Republic	0.03	0.03	0.00	0.02	0.00	0.03
Denmark	0.02	0.01	0.00	0.02	0.00	0.02
Estonia	0.09	0.08	0.07	0.09	0.07	0.09
Finland	0.04	0.04	-0.02	-0.01	-0.02	-0.01
France	0.01	0.01	0.00	0.01	-0.01	0.01
Germany	0.02	0.01	0.04	0.09	0.03	0.09
Greece	0.04	0.04	0.01	0.02	0.00	0.02
Hungary	0.03	0.02	0.01	0.04	0.01	0.04
Ireland	0.11	0.10	-0.01	0.05	-0.01	0.04
Italy	0.01	0.01	0.00	0.00	0.00	0.00
Latvia	0.16	0.16	0.13	0.14	0.13	0.14
Lithuania	0.06	0.06	0.01	0.09	0.01	0.09
Luxembourg	0.04	0.04	0.03	-0.02	0.02	-0.02
Malta	2.95	2.95	0.10	0.18	0.10	0.18
Netherlands	0.02	0.02	0.03	0.06	0.03	0.05
Poland	0.02	0.02	-0.01	0.02	-0.01	0.02
Portugal	0.04	0.04	-0.02	0.00	-0.02	0.00
Romania	0.01	0.01	0.01	0.01	0.01	0.01
Slovakia	0.03	0.03	0.00	0.02	0.00	0.02
Slovenia	0.08	0.08	0.05	0.06	0.05	0.06
Spain	0.01	0.00	0.01	0.03	0.01	0.03
Sweden	0.02	0.01	0.01	0.03	0.01	0.03
UK	0.05	0.05	0.01	0.08	0.01	0.07
EU27	0.03	0.02	0.01	0.04	0.01	0.04

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in price levels

At a national level there is virtually no change in inflation and price levels in 2020 and 2030. The largest observed impact in any country was 0.03%, which compares to an annual target in the range of 2-3%.

A small increase in the price level in some sectors is expected, given the increase in demand that the additional investment will directly create for specific sectors. Those sectors that will be directly involved in the creation of the new interconnections show the largest increases in prices in 2020 and 2030, such as mechanical engineering, other business services and construction:

- In ES1 and ES3 construction prices increase by 0.11% in 2020, mechanical engineering prices by 0.10% and other business services prices by 0.04%.
- In these scenarios in 2030 prices increase by slightly less as the additional investment slows; by 0.04% in construction, 0.02% in mechanical engineering and 0.02% in other business services.
- In 2030 in ES2 and ES4, however, construction prices increase by 0.21%, mechanical engineering prices increase by 0.12% and other business services prices increase by 0.03%.

Changes in sectoral output

The same sectors also see some of the largest increases in output given the increase in demand for their goods and services. These results are presented in Table 7.7. In 2020 the output results are all positive in both ES1 and ES3.

In 2030, output in some sectors in ES1 and ES3 falls due to dynamic effects from falling investment. However, output increases in ES2 and ES4, particularly for those sectors that could be heavily involved in the new infrastructure, such as mechanical engineering, construction and electronics.

TABLE 7.7: IMPACT ON SECTORAL OUTPUT, 2020 AND 2030 (EU27)

	2020		**2030**			
	ES1	**ES3**	**ES1**	**ES2**	**ES3**	**ES4**
Agriculture	0.00	0.00	0.00	0.01	0.00	0.01
Coal	0.05	0.05	0.09	0.37	0.52	0.42
Oil & Gas	0.00	0.00	0.00	0.00	0.00	0.00
Other Mining	0.01	0.01	0.00	0.00	0.00	0.00
Food, Drink and Tobacco	0.01	0.00	0.01	0.02	0.01	0.02
Textiles, Clothing & Leather	0.04	0.04	0.04	0.17	0.04	0.17
Wood & Paper	0.07	0.06	0.00	0.04	0.00	0.04
Printing & Publishing	0.02	0.02	0.03	0.06	0.03	0.06
Manufactured Fuels	0.04	0.04	0.02	0.10	0.02	0.09
Pharmaceuticals	0.04	0.03	-0.03	0.02	-0.03	0.01
Chemicals nes	0.03	0.03	-0.06	-0.07	-0.06	-0.07
Rubber & Plastics	0.10	0.10	0.00	0.12	0.00	0.12
Non-Metallic Mineral Products	0.01	0.01	-0.01	-0.01	-0.01	-0.01
Basic Metals	0.08	0.08	0.04	0.12	0.04	0.12
Metal Goods	0.11	0.11	0.06	0.25	0.06	0.25
Mechanical Engineering	0.20	0.20	0.09	0.44	0.09	0.43
Electronics	0.22	0.22	0.02	0.25	0.02	0.25
Electrical Engineering & Instruments	0.03	0.03	0.01	0.05	0.01	0.05
Motor Vehicles	0.02	0.02	0.00	0.07	-0.02	0.06
Other Transport Equipment	0.03	0.03	0.00	0.03	0.00	0.03
Manufacturing nes	0.04	0.04	0.01	0.08	0.01	0.08
Electricity	0.03	0.03	0.00	0.04	0.00	0.04
Gas Supply	0.04	0.04	-0.01	-0.66	0.00	-0.64
Water Supply	0.01	0.00	0.01	0.03	0.01	0.03
Construction	0.25	0.24	0.06	0.35	0.06	0.35
Distribution	0.05	0.05	0.01	0.08	0.01	0.08
Retailing	0.03	0.02	0.01	0.06	0.01	0.06
Hotels & Catering	0.00	0.00	0.01	0.01	0.01	0.01
Land Transport	0.03	0.03	0.00	0.04	0.00	0.04
Water Transport	0.02	0.02	-0.01	0.05	-0.01	0.05
Air Transport	0.02	0.02	0.04	0.09	0.04	0.09
Communications	0.06	0.05	0.01	0.11	0.01	0.10
Banking & Finance	0.05	0.04	0.01	0.09	0.01	0.09
Insurance	0.04	0.04	0.04	0.13	0.04	0.13
Computing Services	0.08	0.07	0.01	0.14	0.01	0.14
Professional Services	0.05	0.05	0.01	0.09	0.01	0.08
Other Business Services	0.07	0.07	0.00	0.12	0.00	0.12
Public Admin &Defence	0.00	0.00	0.00	0.01	0.00	0.01
Education	0.00	0.00	0.01	0.01	0.01	0.01
Health & Social Work	0.00	0.00	0.00	0.01	0.00	0.01
Miscellaneous Services	0.04	0.03	0.02	0.07	0.02	0.07
Total	0.06	0.05	0.01	0.09	0.01	0.09

Note(s): Figures are % difference from base case.

TABLE 7.7: IMPACT ON SECTORAL OUTPUT, 2020 AND 2030 (EU27)

	2020		2030			
	ES1	ES3	ES1	ES2	ES3	ES4

Source(s): E3ME, Cambridge Econometrics.

Distributional impacts

Table 7.8 presents the change in real incomes each scenario will bring about in 2020 and 2030.This allows for an analysis of the distributional effects of the different investment options.

In 2020, ES1 and ES3 result in no noteworthy distributional effects, as the increase in incomes is the same across all income quintiles and socio-economic groups. This is also the case in the results for 2030.

TABLE 7.8: DISTRIBUTIONAL EFFECTS, 2020 AND 2030 (EU27)

	2020		2030			
	ES1	ES3	ES1	ES2	ES3	ES4
All households	0.02	0.02	0.01	0.04	0.00	0.04
First quintile	0.02	0.02	0.01	0.04	0.01	0.04
Second quintile	0.02	0.02	0.01	0.04	0.01	0.04
Third quintile	0.02	0.02	0.01	0.05	0.01	0.04
Fourth quintile	0.02	0.02	0.01	0.05	0.01	0.04
Fifth quintile	0.02	0.02	0.00	0.04	0.00	0.04
Manual workers	0.02	0.02	0.01	0.05	0.01	0.05
Non-manual workers	0.02	0.02	0.01	0.05	0.01	0.05
Self-employed	0.02	0.02	0.00	0.04	0.00	0.04
Unemployed	0.02	0.01	0.00	0.03	0.00	0.03
Retired	0.02	0.01	0.00	0.03	0.00	0.02
Inactive	0.01	0.01	0.00	0.02	0.00	0.02
Densely populated	0.02	0.02	0.01	0.04	0.00	0.04
Sparsely populated	0.02	0.02	0.00	0.04	0.00	0.04

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in energy demand

The results in Table 7.9 demonstrate that building the additional electricity interconnections will have a very small, positive impact on energy demand in both scenarios in 2020. For the EU27 in total, across all fuel users, a modest 0.01% increase is expected in ES1 and ES3. In the E3ME classifications, construction is part of ‘Other Industry’, so this sector is linked to the investments.

Since economic activity is lower for many countries in ES1 and ES3 in 2030, on account of the lower levels of investment in these scenarios, the change in energy demand is expected to be lower across all fuel users than in 2020. The opposite is true in ES2 and ES4, due to higher levels of investment, and output in many sectors.

TABLE 7.9: CHANGE IN ENERGY DEMAND, 2020 AND 2030 (EU27)

	2020		**2030**			
	ES1	**ES3**	**ES1**	**ES2**	**ES3**	**ES4**
Power generation	0.01	0.01	-0.02	0.05	0.06	0.13
Other energy own use & trans.	0.01	0.01	0.00	0.01	0.00	0.01
Iron & steel	0.03	0.03	0.00	0.03	0.00	0.03
Non-ferrous metals	0.03	0.03	0.02	0.05	0.02	0.04
Chemicals	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02
Non-metallics	0.01	0.01	-0.02	0.00	-0.02	0.00
Ore-extraction (non-energy)	0.01	0.01	-0.01	-0.02	0.00	-0.01
Food, drink &tobacco	0.00	0.00	0.00	0.00	0.00	0.00
Textiles, clothing&footwear	0.01	0.01	0.00	0.02	0.00	0.01
Paper & pulp	0.04	0.03	-0.01	0.01	-0.02	0.01
Engineering	0.03	0.03	0.01	0.05	0.00	0.04
Other industry	0.04	0.05	0.01	0.04	0.00	0.01
Rail transport	0.00	0.00	0.01	0.01	0.00	0.00
Road transport	0.04	0.04	0.02	0.08	0.02	0.07
Air transport	0.02	0.02	0.03	0.08	0.03	0.08
Other transport services	0.00	0.00	0.00	0.01	0.00	0.01
Households	0.01	0.00	0.00	0.01	0.00	0.00
Other final use	0.02	0.02	0.00	0.00	-0.01	-0.01
Non-energy use	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.02	0.02	0.00	0.03	0.02	0.05

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

The increased economic activity that the additional electricity investment brings about will tend to add to the level of emissions of greenhouse gases (GHGs).The results show a small increase in emissions of carbon dioxide and other GHGs in 2020.In 2030 emissions are lower in ES1 compared to the base case due to the lower levels of investment.However, in ES2 and ES4, which represent higher levels of investment, increases in emissions of GHGs are observed. These are mainly the result of transport and construction activities to build the new grid infrastructure. However, these small increases in emissions are negligible compared to the emission reduction effect, which comes from the new renewable technologies included in the scenarios and which is not assessed in the E3ME model.

7.3 Results from the gas scenarios

Scenario definitions

Like the electricity scenarios, the main input to scenarios GS1 to GS4 is an increase in investment. In GS1 it is assumed that investment in gas infrastructure is made by private companies alone but without an impact on energy prices. In GS2 a secondary impact on gas prices is assumed, since the increase in supply to the EU as a result of investment leads to lower prices. GS3 and GS4 are identical to GS1 and GS2 respectively, except that it is assumed that 5% of the additional investment is paid from public funds. In these scenarios a very small increase in direct taxes is imposed in order to maintain revenue neutrality.

Macroeconomic impacts

Tables 7.10 and 7.11 present a summary of the macroeconomic impacts for 2020 and 2030 respectively. As expected, in GS1 and GS3 investment is affected by more than the other components of GDP, with an increase of 0.04% in 2020 compared to the base case.

The change in overall investment in GS2 and GS4 is also 0.04%. However, in these scenarios household spending is affected the most, with a change of 0.10% expected in 2020. This is due to increases in real incomes that result from the lower gas prices assumed. As household spending increases, so too does spending on imports (ie some household goods are imported), hence the increase in GS2 and GS4; this is compounded by higher imports of natural gas.

Lower gas prices in GS2 and GS4 feed into costs in other sectors, resulting in an overall fall in consumer prices of 0.17% across the EU27 in 2020. This is also favourable for international competitiveness, so a greater increase in exports is observed in GS2 and GS4 compared to GS1 and GS3. All things considered, the impact on GDP is much larger in GS2 and GS4, with an increase of 0.09% expected in 2020. This compares to an increase of just 0.02% in GS1 and GS3. The conclusion is that the effects of a change in energy prices could outweigh the effects of investment in additional infrastructure.

The results for 2030 follow a similar pattern, as Table 7.11 shows. However, the macroeconomic impacts are in most cases larger than in 2020. This suggests that the effects of the additional infrastructure investment increase in intensity over time.

TABLE 7.10: SUMMARY OF MACROECONOMIC IMPACTS, 2020 (EU27)

	GS1	GS2	GS3	GS4
GDP	0.02	0.09	0.02	0.09
Household spending	0.01	0.10	0.01	0.10
Investment	0.04	0.04	0.04	0.04
Exports	0.01	0.07	0.01	0.07
Imports	0.01	0.03	0.01	0.03
Employment	0.01	0.03	0.01	0.03
Prices	0.00	-0.17	0.00	-0.17

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

TABLE 7.11: SUMMARY OF MACROECONOMIC IMPACTS, 2030 (EU27)

	GS1	GS2	GS3	GS4
GDP	0.01	0.10	0.01	0.10
Household spending	0.01	0.11	0.01	0.11
Investment	0.01	0.07	0.01	0.07
Exports	0.00	0.09	0.00	0.09
Imports	0.00	0.06	0.00	0.06
Employment	0.00	0.06	0.00	0.06
Prices	-0.01	-0.16	-0.01	-0.16

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in investment

Table 7.12 presents the impact on investment for each Member State. Again, this includes the exogenous increase in infrastructure investment as well as secondary effects. It is therefore unsurprising that the impact on investment is greatest in those countries in which the largest gas infrastructure investments are due to take place, such as Bulgaria and Hungary.

In GS2 and GS4 investment falls slightly in some countries. The reason for this stems from the lower gas prices in these scenarios. This makes energy relatively cheaper than capital, causing some switching (e.g. delaying purchases in energy-efficient equipment). In some countries this effect outweighs the effect of growing output leading to increased investment demand, so there is a net reduction.

TABLE 7.12: IMPACT ON INVESTMENT, 2020

	GS1	GS2	GS3	GS4
Austria	0.13	0.12	0.13	0.12
Belgium	0.01	0.03	0.01	0.03
Bulgaria	1.27	1.22	1.27	1.22
Cyprus	0.01	0.01	0.01	0.01
Czech Republic	0.01	-0.02	0.01	-0.02
Denmark	0.01	-0.03	0.01	-0.03
Estonia	0.05	0.10	0.05	0.10
Finland	0.00	-0.02	0.00	-0.02
France	0.03	0.02	0.03	0.02
Germany	0.10	0.13	0.10	0.13
Greece	0.03	0.05	0.03	0.05
Hungary	0.27	0.29	0.27	0.29
Ireland	0.00	0.01	0.00	0.01
Italy	0.03	-0.03	0.03	-0.03
Latvia	0.01	-0.07	0.01	-0.07
Lithuania	0.01	-0.04	0.01	-0.04
Luxembourg	0.00	0.00	0.00	0.00
Malta	0.00	-0.03	0.00	-0.03
Netherlands	0.01	0.11	0.01	0.11
Poland	0.01	0.01	0.01	0.01
Portugal	0.01	0.02	0.01	0.02
Romania	0.36	0.33	0.36	0.33
Slovakia	0.01	-0.06	0.01	-0.06
Slovenia	0.01	-0.05	0.01	-0.05
Spain	0.03	0.06	0.03	0.06
Sweden	0.00	0.03	0.00	0.03
UK	0.01	-0.03	0.01	-0.03
EU27	0.04	0.04	0.04	0.04

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Impact on GDP

Table 7.13 gives a breakdown of the increase in GDP for each of the EU27 Member States, while Figure 7.2 shows the impact on GDP for the EU27 as a whole and the profile of the changes over 2010-20.The largest increases in GDP are observed in those countries in which the new gas infrastructure is expected to take place, such as Bulgaria and Romania.The reason for this is that these countries will be directly affected by increased activity in certain sectors such as construction and mechanical engineering, which will be involved in the production of the new pipelines.The highest increase in GDP in GS1 is in Bulgaria (0.17%).

The increases in GDP are larger in GS2 and GS4, for the same reasons mentioned previously. In these scenarios households experience an increase in their real incomes as a result of lower prices, and for that reason household consumption increases (see below). Firms also incur lower costs due to the reduced gas prices, and are therefore more competitive internationally. This leads to an increase in exports and, together with an increase in household expenditure, GDP is boosted. The change in financing method does not have a noticeable impact on the results, so we see little difference between GS1 and GS3, and between GS2 and GS4.

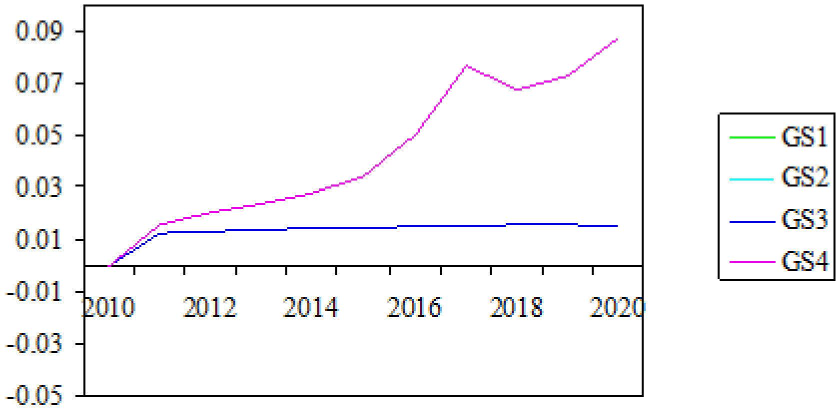
The Czech Republic, Estonia and Slovakia all see a fall in GDP in GS2 and GS4. This occurs since imports of gas increase as a result of the lower prices. The trade balance is therefore worsened, reducing GDP.

TABLE 7.13: IMPACT ON GDP, 2020

	GS1	GS2	GS3	GS4
Austria	0.03	0.04	0.03	0.04
Belgium	0.01	0.08	0.01	0.08
Bulgaria	0.17	0.12	0.17	0.12
Cyprus	0.01	0.05	0.01	0.05
Czech Republic	0.01	-0.04	0.01	-0.04
Denmark	0.00	0.00	0.00	0.00
Estonia	0.02	-0.01	0.02	-0.01
Finland	0.00	0.00	0.00	0.00
France	0.01	0.04	0.01	0.04
Germany	0.03	0.13	0.03	0.13
Greece	0.01	0.04	0.01	0.04
Hungary	0.08	0.08	0.08	0.08
Ireland	0.01	0.12	0.01	0.12
Italy	0.01	0.02	0.01	0.02
Latvia	0.01	0.04	0.01	0.04
Lithuania	0.01	0.02	0.01	0.02
Luxembourg	0.02	0.11	0.02	0.11
Malta	0.00	0.02	0.00	0.02
Netherlands	0.01	0.10	0.01	0.10
Poland	0.01	0.08	0.01	0.08
Portugal	0.00	0.06	0.00	0.06
Romania	0.08	0.27	0.08	0.27
Slovakia	0.00	-0.22	0.00	-0.22
Slovenia	0.01	0.02	0.01	0.02
Spain	0.01	0.06	0.01	0.06
Sweden	0.01	0.04	0.01	0.04
UK	0.01	0.18	0.01	0.18
EU27	0.02	0.09	0.02	0.09

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

FIGURE 7.2: EU27 GDP FOR EACH GAS SCENARIO, % DIFFERENCE FROM BASE CASE



Source(s) : E3ME, Cambridge Econometrics.

Changes in household spending The impact on household spending in each Member State is much greater in GS2 and GS4, as Table 7.14 demonstrates and, in macroeconomic terms, this is the main impact of lower gas prices. Those countries that will benefit the most from the increased gas supply and lower gas prices in these scenarios see the largest rises in household spending in 2020. For example, household spending increases by 0.13% in the Netherlands and by 0.17% in Germany in GS2 and GS4.

TABLE 7.14: IMPACT ON HOUSEHOLD SPENDING, 2020

	GS1	GS2	GS3	GS4
Austria	0.00	0.06	0.00	0.06
Belgium	0.01	0.16	0.01	0.16
Bulgaria	0.01	0.11	0.01	0.11
Cyprus	0.00	0.04	0.00	0.04
Czech Republic	0.00	0.03	0.00	0.03
Denmark	0.00	0.03	0.00	0.03
Estonia	0.00	0.02	0.00	0.02
Finland	0.00	0.03	0.00	0.03
France	0.00	0.05	0.00	0.05
Germany	0.02	0.17	0.02	0.17
Greece	0.00	0.04	0.00	0.04
Hungary	0.03	0.07	0.03	0.07
Ireland	0.01	0.10	0.01	0.10
Italy	0.00	0.05	0.00	0.05
Latvia	0.00	0.08	0.00	0.08
Lithuania	0.01	0.08	0.01	0.08
Luxembourg	0.00	0.10	0.00	0.10
Malta	0.00	0.05	0.00	0.05
Netherlands	0.00	0.13	0.00	0.13
Poland	0.00	0.10	0.00	0.10
Portugal	0.01	0.10	0.01	0.10
Romania	0.03	0.04	0.03	0.04
Slovakia	0.00	0.08	0.00	0.08
Slovenia	0.00	0.04	0.00	0.04
Spain	0.00	0.05	0.00	0.05
Sweden	0.00	0.05	0.00	0.05
UK	0.00	0.15	0.00	0.15
EU27	0.01	0.10	0.01	0.10

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in employment

The impacts on employment in Scenarios GS1-GS4 are very small, as Table 7.15 demonstrates. However, it can be noted that employment increases slightly more in GS2 and GS4 compared to GS1 and GS3. This is to be expected since employment not only receives a direct boost from the work surrounding the construction of the new gas infrastructure, but jobs will also indirectly be created via increased household spending in other sectors. In GS2 and GS4 the increases in employment range from 0.01% in several Member States, to 0.08% in Bulgaria.

There is no noticeable change in average wage rates.

TABLE 7.15: IMPACT ON EMPLOYMENT, 2020

	GS1	GS2	GS3	GS4
Austria	0.01	0.02	0.01	0.02
Belgium	0.00	0.03	0.00	0.03
Bulgaria	0.08	0.10	0.08	0.10
Cyprus	0.00	0.00	0.00	0.00
Czech Republic	0.00	0.01	0.00	0.01
Denmark	0.00	0.00	0.00	0.00
Estonia	0.00	0.00	0.00	0.00
Finland	0.00	0.00	0.00	0.00
France	0.00	0.01	0.00	0.01
Germany	0.02	0.07	0.02	0.07
Greece	0.01	0.01	0.01	0.01
Hungary	0.01	0.04	0.01	0.04
Ireland	0.00	0.05	0.00	0.05
Italy	0.00	0.03	0.00	0.03
Latvia	0.00	0.02	0.00	0.02
Lithuania	0.01	0.00	0.01	0.00
Luxembourg	0.01	0.04	0.01	0.04
Malta	0.00	0.01	0.00	0.01
Netherlands	0.00	0.02	0.00	0.02
Poland	0.01	0.03	0.01	0.03
Portugal	0.01	0.01	0.01	0.01
Romania	0.01	0.02	0.01	0.02
Slovakia	0.00	0.02	0.00	0.02
Slovenia	0.00	0.00	0.00	0.00
Spain	0.00	0.01	0.00	0.01
Sweden	0.00	0.01	0.00	0.01
UK	0.00	0.05	0.00	0.05
EU27	0.01	0.03	0.01	0.03

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in prices

The investment in GS1 and GS3 has virtually no impact on consumer prices. However, consumer prices decrease in all Member States in GS2 and GS4, as Table 7.16 shows. Price falls occur as a result of increased gas supply and hence lower gas prices. These lower prices feed into prices within other sectors of the economy, and the end result is a fall in overall consumer price levels.

Hungary sees the greatest fall in prices in GS2 and GS4 (-0.34%), while other countries such as the UK (-0.28%) and Germany (-0.21%) also observe price falls that are greater than the EU average. Price falls tend to be greatest in countries that use gas intensively, particularly in households.

TABLE 7.16: IMPACT ON PRICES, 2020

	GS1	GS2	GS3	GS4
Austria	0.00	-0.09	0.00	-0.09
Belgium	0.00	-0.12	0.00	-0.12
Bulgaria	0.00	-0.07	0.00	-0.07
Cyprus	0.00	-0.07	0.00	-0.07
Czech Republic	-0.01	-0.18	-0.01	-0.18
Denmark	0.00	-0.12	0.00	-0.12
Estonia	0.00	-0.08	0.00	-0.08
Finland	0.00	-0.06	0.00	-0.06
France	0.01	-0.10	0.01	-0.10
Germany	0.00	-0.21	0.00	-0.21
Greece	-0.01	-0.06	-0.01	-0.06
Hungary	-0.01	-0.34	-0.01	-0.34
Ireland	0.00	-0.16	0.00	-0.16
Italy	0.00	-0.17	0.00	-0.17
Latvia	0.00	-0.14	0.00	-0.14
Lithuania	0.00	-0.17	0.00	-0.17
Luxembourg	0.00	-0.21	0.00	-0.21
Malta	-0.01	-0.05	-0.01	-0.05
Netherlands	0.00	-0.15	0.00	-0.15
Poland	0.00	-0.20	0.00	-0.20
Portugal	0.00	-0.09	0.00	-0.09
Romania	0.00	-0.16	0.00	-0.16
Slovakia	0.00	-0.25	0.00	-0.25
Slovenia	0.00	-0.12	0.00	-0.12
Spain	0.00	-0.08	0.00	-0.08
Sweden	0.00	-0.07	0.00	-0.07
UK	0.00	-0.28	0.00	-0.28
EU27	0.00	-0.17	0.00	-0.17

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in sectoral output

Table 7.17 presents the changes in output for 42 sectors of the economy, for the EU27 as a whole. For all scenarios, the change in sectoral output is high in mechanical engineering, construction and other business services, all sectors that would be heavily involved in building the new gas infrastructure. In GS2 and GS4 sectors such as textiles, clothing and leather and retailing also see comparatively large increases in output. This is due to the increased real incomes that these scenarios bring about, and the greater demand consumers will therefore have for these sectors' products. Coal is the only sector to see a decrease in output, due to the fact that gas prices have been reduced, so fuel users are switching away from other forms of energy.

TABLE 7.17: IMPACT ON SECTORAL OUTPUT, 2020 (EU27)

	GS1	**GS2**	**GS3**	**GS4**
Agriculture	0.00	0.06	0.00	0.06
Coal	0.02	-0.29	0.02	-0.29
Oil & Gas	0.00	0.00	0.00	0.00
Other Mining	0.00	0.00	0.00	0.00
Food, Drink and Tobacco	0.00	0.05	0.00	0.05
Textiles, Clothing & Leather	0.01	0.15	0.01	0.15
Wood & Paper	0.02	0.08	0.02	0.08
Printing & Publishing	0.01	0.06	0.01	0.06
Manufactured Fuels	0.01	0.09	0.01	0.09
Pharmaceuticals	0.01	0.08	0.01	0.08
Chemicals nes	0.00	0.04	0.00	0.04
Rubber & Plastics	0.02	0.05	0.02	0.05
Non-Metallic Mineral Products	0.00	0.04	0.00	0.04
Basic Metals	0.02	0.01	0.02	0.01
Metal Goods	0.03	0.03	0.03	0.03
Mechanical Engineering	0.07	0.08	0.07	0.08
Electronics	0.05	0.11	0.05	0.11
Electrical Engineering & Instruments	0.01	0.07	0.01	0.07
Motor Vehicles	0.01	0.04	0.01	0.04
Other Transport Equipment	0.00	0.05	0.00	0.05
Manufacturing nes	0.01	0.05	0.01	0.05
Electricity	0.01	0.03	0.01	0.03
Gas Supply	0.01	1.71	0.01	1.71
Water Supply	0.00	0.08	0.00	0.08
Construction	0.05	0.09	0.05	0.09
Distribution	0.01	0.07	0.01	0.07
Retailing	0.01	0.11	0.01	0.11
Hotels & Catering	0.00	0.06	0.00	0.06
Land Transport	0.01	0.07	0.01	0.07
Water Transport	0.00	0.02	0.00	0.02
Air Transport	0.01	0.03	0.01	0.03
Communications	0.02	0.14	0.02	0.14
Banking & Finance	0.02	0.08	0.02	0.08
Insurance	0.02	0.06	0.02	0.06
Computing Services	0.02	0.07	0.02	0.07
Professional Services	0.01	0.10	0.01	0.10
Other Business Services	0.02	0.09	0.02	0.09
Public Admin &Defence	0.00	0.01	0.00	0.01
Education	0.00	0.01	0.00	0.01
Health & Social Work	0.00	0.02	0.00	0.02
Miscellaneous Services	0.01	0.09	0.01	0.09
Total	0.02	0.07	0.02	0.07

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in sectoral prices

A breakdown of changes in prices for selected sectors is given in Table 7.18. Prices do not change a great deal in GS1 and GS3 for the same reasons mentioned previously.

In almost all cases prices decrease in GS2 and GS4.Those sectors that observe the largest falls in prices are generally energy-intensive sectors such as electricity (-1.45%), basic metals (-0.53%) and non-metallic mineral products (-0.34%), all sectors that will benefit the most from reduced gas prices.It is assumed that these lower gas prices are passed on the form of lower electricity prices in countries that rely on gas-fired plant.

TABLE 7.18: IMPACT ON SELECTED SECTORAL PRICES, 2020 (EU27)

	GS1	GS2	GS3	GS4
Agriculture	0.00	-0.17	0.00	-0.17
Wood & Paper	0.00	-0.23	0.00	-0.23
Chemicals nes	0.00	-0.21	0.00	-0.21
Non-Metallic Mineral Products	0.00	-0.34	0.00	-0.34
Basic Metals	-0.01	-0.53	-0.01	-0.53
Metal Goods	-0.01	-0.19	-0.01	-0.19
Motor Vehicles	0.00	-0.14	0.00	-0.14
Electricity	0.00	-1.45	0.00	-1.45
Total	0.00	-0.14	0.00	-0.14

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Distributional impacts

Table 7.19 presents the change in real incomes that each scenario will bring about, allowing for an analysis of the distributional effects of the different investment options.

GS1 and GS3 will result in hardly any distributional effects at all. This is unsurprising since in these scenarios the additional investment only affects the business side of the economy, and has no effect on households. On the other hand, households are affected by infrastructure investment in GS2 and GS4 because of the secondary impact that it will have on gas prices. The differences in income changes between the five income quintiles are small, with all groups seeing an increase in their real incomes in the range of 0.07% - 0.13%. What is noticeable, however, is that lower income groups see larger increases in income than the highest income groups. This is because these groups spend a greater proportion of their incomes on fuel meaning that, if gas prices decrease, their real incomes increase by a larger amount. Even so, the effects are small at the European level.

TABLE 7.19: DISTRIBUTIONAL EFFECTS, 2020(EU27)

	GS1	GS2	GS3	GS4
All households	0.01	0.10	0.01	0.10
First quintile	0.01	0.13	0.01	0.13
Second quintile	0.01	0.12	0.01	0.12
Third quintile	0.01	0.11	0.01	0.11
Fourth quintile	0.01	0.09	0.01	0.09
Fifth quintile	0.01	0.07	0.01	0.07
Manual workers	0.01	0.09	0.01	0.09
Non-manual workers	0.01	0.07	0.01	0.07
Self-employed	0.00	0.08	0.00	0.08
Unemployed	0.00	0.12	0.00	0.12
Retired	0.00	0.14	0.00	0.14
Inactive	0.00	0.14	0.00	0.14
Densely populated	0.01	0.09	0.01	0.09
Sparsely populated	0.00	0.10	0.00	0.10

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in energy demand

Energy demand does not change a great deal in GS1 and GS3, as shown in Table 7.20. Most fuel users increase their demand for gas in GS2 and GS4. This is to be expected since in these scenarios gas prices are reduced. The largest increase in demand comes from sectors that are dependent on gas as a source of energy. A large fall in demand occurs in the power generation sector (-2.66%) because other fuel users are switching from electricity to gas. Demand within the power generation sector will therefore be lower, and so this sector will use less gas itself. The other sectors where demand does not change are those that do not use gas, mainly transport sectors.

TABLE 7.20: CHANGE IN ENERGY DEMAND, 2020 (EU27)

	GS1	GS2	GS3	GS4
Power generation	0.00	-2.66	0.00	-2.66
Other energy own use and trans.	0.00	1.52	0.00	1.52
Iron & steel	0.01	1.31	0.01	1.31
Non-ferrous metals	0.00	1.97	0.00	1.97
Chemicals	0.00	1.70	0.00	1.70
Non-metallics	0.00	1.60	0.00	1.60
Ore-extraction (non-energy)	0.00	1.37	0.00	1.37
Food, drink &tobacco	0.00	1.79	0.00	1.79
Textiles, clothing&footwear	0.00	2.82	0.00	2.82
Paper & pulp	0.01	1.59	0.01	1.59
Engineering	0.01	1.77	0.01	1.77
Other industry	0.01	2.84	0.01	2.84
Rail transport	0.00	0.60	0.00	0.60
Road transport	0.01	-0.02	0.01	-0.02
Air transport	0.00	-0.03	0.00	-0.03
Other transport services	0.00	1.37	0.00	1.37
Households	0.00	1.04	0.00	1.04
Other final use	0.01	2.25	0.01	2.25
Non-energy use	0.00	0.00	0.00	0.00
Total	0.00	0.22	0.00	0.22

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

E3ME only does a partial analysis of the impact on emissions. In GS1 and GS3, no changes in emissions occur compared to the base case.In GS2 and GS4 there is an increase in emissions from gas, but this is more than compensated by a reduction in emissions from coal due to switching in the power sector.Overall then, there is a decrease in the level of emissions in these scenarios.

The crisis scenarios: Scenario definitions

The crisis scenarios were designed to put the previous set of results into context. Instead of showing the modest economic impacts of investment in new infrastructure, these scenarios show the potentially high cost of inaction. It must be stressed that the results should be considered indicative only, as they are based on a set of fairly arbitrary assumptions surrounding a scenario which is uncertain by definition; however, they do provide an indication of the scale of possible impacts.

Throughout these scenarios it is assumed that there is a loss of supply for two weeks and that this two-week period is representative of the whole year. In GS5 the loss of supply is met by storage (so there is no impact on economic activity other than replenishing stocks over the year), in GS6 and GS7 it is assumed that storage is not adequate and supplies may be lost to industry (GS6) and to industry and households (GS6 and GS7).

How much are sectors affected?

Table 7.21 provides an estimate of exposure to a reduction in supplies. We work on the basis that supplies will first be cut to electricity suppliers who can switch to alternative fuels[58], then industry, then households and other electricity producers.

This is compared to the exposure to gas from the Ukraine, to see where the supply reductions would occur. For example, in the Czech Republic:

- up to 40% of gas that is consumed comes from the Ukraine
- there is little potential for fuel switching in the electricity sector (only 10% of total gas consumption)
- therefore industry can also expect to lose supplies, counting for a further 30%
- but households should not see supplies cut off

The difference between GS6 and GS7 is the last of these bullet points, whether households would ever lose supplies. As Table 7.21 shows, under these assumptions only one country, Greece, would be in this situation, and it would only lose a small share of supply to households (2% out of 32%).

However, it should be noted that other countries would be affected more if they were not able to rapidly switch electricity generation from gas to alternative fuels.

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[58] This could be described as the painless loss of production. The size of additional capacity is estimated by increasing load factors in coal and oil plants to 90% over the two-week period.

TABLE 7.21: EXPOSURE TO GAS FROM UKRAINE, 2020

	Share of domestic gas consumption, %			
	Electricity generation that can use other fuels	**Industry**	**Households and other electricity production**	**Share of gas coming from Ukraine, %**
Austria	22	54	24	25
Belgium	23	52	26	0
Bulgaria	26	70	4	60
Cyprus	100	0	0	0
Czech Republic	10	65	25	40
Denmark	37	48	14	0
Estonia	14	77	9	0
Finland	43	48	9	0
France	17	49	34	10
Germany	21	36	43	15
Greece	60	8	32	70
Hungary	35	34	31	60
Ireland	8	30	62	0
Italy	17	33	50	20
Latvia	21	60	19	0
Lithuania	54	36	10	0
Luxembourg	0	36	64	0
Malta	95	5	0	0
Netherlands	37	41	22	0
Poland	8	63	29	25
Portugal	51	40	9	0
Romania	24	58	18	15
Slovakia	10	67	23	70
Slovenia	19	72	9	30
Spain	45	44	11	0
Sweden	31	65	5	0
UK	15	31	55	0

Source(s) : All figures are estimates, based on data from the E3ME model, European Commission, authors' own calculations.

Model inputs

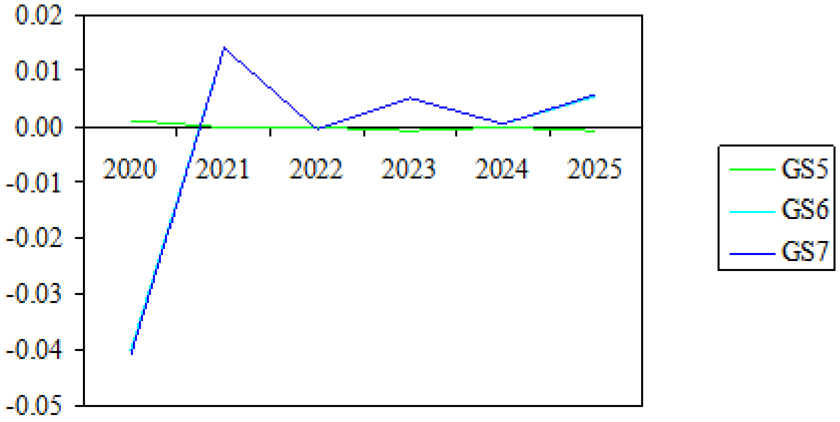
The inferred reduction in gas inputs was translated into a reduction in economic output (split equally between exports and domestic production) in the manufacturing sectors, with the assumption that 50% of production relies on gas as an input. This was then multiplied by 0.04 (ie two weeks out of 52) to get an annual loss of production and entered to E3ME as a shock in 2020. The results below show the final impacts including secondary effects.

In GS7, where households and remaining electricity production (the part that would lead to cuts in generation rather than generation from alternative fuels) are affected, we reduce household spending on energy and economic output of the electricity industry. In addition, the remaining 50% of manufacturing production is also affected (it seems unlikely that much activity would take place without gas or electricity). Our assumption is that service industries are not directly affected but it is not difficult to see how this could be the case, which would increase the scale of results further (although in these scenarios only in Greece).

Model results

Figure 7.3 below shows GDP for the EU27 in GS5, GS6 and GS7 as a percentage difference from base case. As the chart demonstrates, GDP hardly changes in GS5, while the changes in GS6 and GS7 are almost identical. In 2020 in these scenarios there is a reduction in GDP of around 0.04%, after which some, but by no means all, of the lost output is made up.

FIGURE 7.3: EU27 GDP FOR EACH GAS CRISIS SCENARIO, % DIFFERENCE FROM BASE CASE



Source(s) : E3ME, Cambridge Econometrics.

Impacts at member-state level

Table 7.22 shows the impact on GDP and employment for each Member State in the gas crisis scenarios. In GS5 it is assumed that the loss of gas supply is met by storage, therefore there is little or no impact on industry and therefore GDP. The loss of supply is assumed to be for two weeks, so the only impact, if any, on economic activity would be caused by efforts to replenish stocks over the year (implying slightly higher final prices for consumers). A small fall in GDP occurs in Bulgaria, Hungary and Greece. In GS5 there is no impact on employment in any of the Member States.

TABLE 7.22: IMPACT ON GDP & EMPLOYMENT, 2020

	GS5		**GS6**		**GS7**	
	GDP	**Employment**	**GDP**	**Employment**	**GDP**	**Employment**
AT	0.01	0.00	-0.07	-0.01	-0.07	-0.01
BE	0.00	0.00	-0.03	0.00	-0.03	0.00
BG	-0.05	0.00	-0.61	0.00	-0.61	0.00
CY	0.00	0.00	-0.02	-0.01	-0.02	-0.01
CZ	0.01	0.00	-0.76	-0.08	-0.76	-0.08
DK	0.00	0.00	0.02	0.03	0.02	0.03
EN	0.00	0.00	0.01	-0.02	0.01	-0.03
FI	0.00	0.00	0.02	0.03	0.02	0.03
FR	0.00	0.00	0.00	0.00	0.00	0.00
DE	0.00	0.00	-0.01	0.00	-0.01	0.00
EL	-0.01	0.00	-0.20	-0.25	-0.25	-0.26
HU	-0.02	0.00	-1.35	-0.05	-1.36	-0.05
IR	0.00	0.00	-0.06	-0.01	-0.06	-0.01
IT	0.00	0.00	-0.01	-0.06	-0.01	-0.06
LV	0.00	0.00	0.01	-0.02	0.01	-0.02
LT	0.00	0.00	0.05	0.05	0.05	0.05
LX	0.00	0.00	-0.06	-0.01	-0.06	-0.01
MT	0.00	0.00	0.01	0.00	0.01	0.00
NL	0.00	0.00	-0.04	0.00	-0.04	-0.01
PL	0.00	0.00	-0.20	-0.06	-0.20	-0.06
PT	0.00	0.00	-0.01	-0.04	-0.01	-0.04
RO	0.00	0.00	-0.07	0.00	-0.07	0.00
SK	0.05	0.00	-0.98	-0.05	-0.98	-0.05
SI	0.01	0.00	-0.18	-0.03	-0.18	-0.03
ES	0.00	0.00	0.00	-0.01	0.00	-0.01
SW	0.00	0.00	-0.02	-0.01	-0.02	-0.01
UK	0.00	0.00	-0.01	0.01	-0.01	0.01
EU27	0.00	0.00	-0.04	-0.02	-0.04	-0.02

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

In GS6 it is assumed that storage capacities are not adequate and that some supply to industry is lost. Economic activity in this scenario will be adversely affected, as the results in Table 7.22 demonstrate. In most cases GDP and employment fall, as a result of disrupted industry production. For the EU27 as a whole, GDP is expected to fall by -0.04%, while employment falls by -0.02%. The largest falls in GDP are seen in Hungary (-1.35%) and Slovakia (-0.98%). This is unsurprising given the large share of these countries' gas supplies coming from the Ukraine (see Table 7.21). The falls in employment in these countries are also relatively large compared to other Member States.

GS7 again assumes that storage is not adequate, with the only difference to GS6 being that gas supply could be lost to households and remaining electricity suppliers, as well as industry. As previously noted, only Greece would be in the situation where supply would be cut to all industry as well as households and remaining electricity suppliers. Since most countries are able to avoid getting to this situation, the impacts on GDP and employment are no different between GS6 and GS7. Greece, on the other hand, experiences a slightly greater loss in GDP and employment in the latter scenario.

In some countries there is a small increase in GDP and employment in the scenarios. This occurs since these countries do not use gas from the Ukraine, meaning that they do not lose out from the cut-off in supply. In fact, they make a small gain from increased EU trade, since competitor countries experience disruption in production.

7.4 Combined scenarios

Introduction

The combined scenarios represent a mixture of electricity infrastructure, gas infrastructure and carbon capture and storage (CCS) investments as well as assumptions regarding the level of EU financing. Further assumptions were made about the timing of the investment in the period up to 2020, and how the investment is shared out between countries. More detail on this are given in Chapter 6.

Macroeconomic impacts

Table 7.23 provides a summary of the cumulative macroeconomic impacts for the combined scenarios across the period 2011-2020. Table 7.24 compares the results to CS1, whereas Table 7.23 presents the results as difference from the base case. It is clear that the effects on the selected macroeconomic variables are positive, although small, in all scenarios.

The main focus of these scenarios is an increase in investment in a combination of electricity and gas infrastructure and CCS and therefore the largest impacts are on investment.Investment is increased the most in CS5 and CS6, which both include much higher levels of gas and electricity infrastructure investment than the other scenarios.

Figure 7.4 shows the GDP results for each combined scenario in 2020. The largest increases in this year are seen in CS5 due to the timing of the investment.Whereas a higher level of investment occurs in CS6, this is spread out equally over a period of ten years (2010-2020).In CS5 on the other hand, three-quarters of the electricity infrastructure investment occurs in the period 2015-2020, therefore the macroeconomic impacts will be greater in 2020.

Increases in investment will generally lead to greater economic activity for several reasons.The investment itself will create the need for greater employment from those sectors involved in the construction of the infrastructures, to carry out the work.This leads to higher incomes in general and greater household spending.Greater demand in consumer sectors will again lead to increased employment and so on.Household spending therefore increases in all scenarios, as does employment.The cumulative impact on the price level is small over the period with the actual difference in prices compared to the base case being less than +/-0.005 across all the scenarios.Looking at a snapshot of 2020 the price impact is in the region of +0.01-0.03% as the positive impact from investment stimulates higher output and inflation, although this is still considered to be very small. This would change, however, if we assumed impacts on energy prices.

TABLE 7.23: CUMULATIVE MACROECONOMIC IMPACTS, 2011-2020 (EU27)

	CS1	CS2	CS3	CS4	CS5	CS6
GDP	0.69	0.95	0.91	1.12	1.28	1.60
Household spending	0.25	0.31	0.32	0.39	0.40	0.49
Investment	2.18	2.96	2.68	3.15	3.59	4.31
Exports	0.31	0.41	0.37	0.45	0.48	0.61
Imports	0.35	0.47	0.41	0.49	0.53	0.65
Employment	0.31	0.39	0.38	0.49	0.48	0.65
Prices*			< +/-0.005			

Note(s): Figures are % difference from base case value in 2020.
*Price results shown are actual cumulative impacts (2000=1.00).
Source(s): E3ME, Cambridge Econometrics.

TABLE 7.24: CUMULATIVE MACROECONOMIC IMPACTS, 2011-2020 (EU27)

	CS2	CS3	CS4	CS5	CS6
GDP	0.26	0.22	0.42	0.59	0.90
Household spending	0.06	0.07	0.15	0.16	0.27
Investment	0.88	0.68	1.30	1.93	2.93
Exports	0.12	0.10	0.21	0.27	0.45
Imports	0.14	0.10	0.21	0.29	0.48
Employment	0.08	0.07	0.18	0.18	0.34
Prices*			< +/-0.005		

Note(s): Figures are % difference from CS1 value in 2020.
*Price results shown are actual cumulative impacts (2000=1.00).
Source(s): E3ME, Cambridge Econometrics.

TABLE 7.25: IMPACT ON INVESTMENT, 2020

	CS1	CS2	CS3	CS4	CS5	CS6
Austria	0.19	0.23	0.30	0.31	0.36	0.37
Belgium	0.07	0.13	0.13	0.13	0.24	0.24
Bulgaria	2.31	3.18	3.49	3.34	5.16	4.89
Cyprus	0.19	0.61	0.22	0.22	1.12	1.04
Czech Republic	0.35	0.41	0.63	0.58	0.73	0.68
Denmark	0.17	0.25	0.34	0.29	0.51	0.44
Estonia	1.39	2.11	2.42	2.24	3.90	3.59
Finland	0.68	0.88	0.95	0.95	1.27	1.28
France	0.17	0.25	0.28	0.25	0.45	0.41
Germany	0.14	0.21	0.27	0.25	0.42	0.39
Greece	0.41	0.57	0.75	0.66	1.08	0.95
Hungary	0.51	0.59	0.88	0.83	1.00	0.95
Ireland	0.15	0.18	0.34	0.25	0.43	0.32
Italy	0.13	0.17	0.22	0.21	0.29	0.29
Latvia	1.88	2.32	3.09	2.91	3.87	3.66
Lithuania	2.03	2.58	3.34	3.13	4.35	4.08
Luxembourg	0.07	0.08	0.14	0.12	0.15	0.14
Malta	18.38	20.70	41.62	36.73	46.74	41.37
Netherlands	0.32	0.41	0.75	0.67	0.96	0.85
Poland	0.45	0.54	0.78	0.72	0.94	0.88
Portugal	0.71	0.93	1.24	1.13	1.67	1.52
Romania	0.59	0.80	0.82	0.81	1.19	1.15
Slovakia	0.40	0.47	0.67	0.64	0.79	0.76
Slovenia	0.72	0.76	1.47	1.33	1.54	1.41
Spain	0.11	0.14	0.19	0.17	0.26	0.23
Sweden	0.58	0.75	0.77	0.74	1.07	1.01
UK	0.21	0.40	0.40	0.41	0.81	0.78
EU27	0.22	0.32	0.39	0.37	0.58	0.54

Note(s): Figures are % difference from base case. They include the exogenous increase in investment defined in the scenarios, plus any induced secondary effects.
Source(s): E3ME, Cambridge Econometrics.

Changes in investment

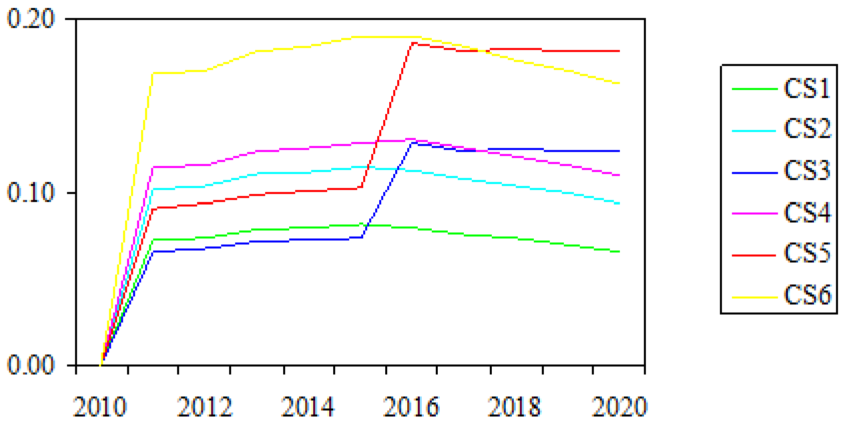
The impact on investment varies across the Member States, as Table 7.25 shows. The largest increase by far occurs in Malta, owing to the costly sub-sea connections. The central and eastern European Member States also see large increases in investment in 2020, both in gas and electricity infrastructure.

Impact on GDP

The impact of the additional investment on GDP for the EU27 is positive, as Figure 7.4 shows. At the Member State level, the changes are positive for all countries, as the breakdown in Table 7.26 shows.What is noteworthy is that the increases in CS5 and CS6 are considerably higher in most Member States compared to the results in Scenarios CS1 to CS4.The largest increases occur in CS5, due to the timing of the investment, as discussed above and shown in the chart.In this scenario, GDP increases by 0.18% in 2020 compared to the base case.This equates to around €26 bn in 2008 prices.

The largest increases in GDP in all of the scenarios are observed in those countries in which the greatest amount of new investment is due to take place, such as Malta, Latvia and Lithuania. These countries will be directly affected by increased activity in certain sectors such as construction and mechanical engineering, which will be involved in the production of electricity and gas infrastructures and CCS technologies (see sectoral results below).

FIGURE 7.4: EU27 GDP FOR EACH COMBINED SCENARIO, % DIFFERENCE FROM BASE CASE



Source(s) : E3ME, Cambridge Econometrics.

TABLE 7.26: IMPACT ON GDP, 2020

	CS1	CS2	CS3	CS4	CS5	CS6
Austria	0.05	0.06	0.1	0.08	0.12	0.09
Belgium	0.04	0.06	0.08	0.07	0.12	0.11
Bulgaria	0.31	0.43	0.46	0.45	0.68	0.66
Cyprus	0.05	0.14	0.06	0.06	0.26	0.24
Czech Republic	0.15	0.19	0.24	0.25	0.30	0.32
Denmark	0.04	0.05	0.09	0.07	0.13	0.10
Estonia	0.44	0.67	0.76	0.72	1.24	1.15
Finland	0.22	0.28	0.29	0.30	0.40	0.41
France	0.03	0.04	0.06	0.05	0.09	0.07
Germany	0.06	0.09	0.11	0.11	0.17	0.16
Greece	0.12	0.16	0.23	0.19	0.31	0.26
Hungary	0.17	0.20	0.30	0.28	0.35	0.33
Ireland	0.13	0.16	0.27	0.22	0.34	0.28
Italy	0.04	0.05	0.06	0.07	0.08	0.09
Latvia	0.73	0.90	1.14	1.14	1.42	1.43
Lithuania	0.60	0.76	1.01	0.92	1.32	1.20
Luxembourg	0.08	0.10	0.15	0.13	0.19	0.17
Malta	1.42	1.59	3.10	2.76	3.48	3.09
Netherlands	0.06	0.08	0.17	0.13	0.22	0.16
Poland	0.16	0.19	0.29	0.26	0.37	0.32
Portugal	0.07	0.09	0.14	0.11	0.18	0.15
Romania	0.14	0.18	0.20	0.20	0.27	0.27
Slovakia	0.18	0.22	0.24	0.28	0.29	0.35
Slovenia	0.16	0.17	0.35	0.29	0.37	0.31
Spain	0.03	0.03	0.09	0.04	0.12	0.05
Sweden	0.18	0.23	0.25	0.24	0.34	0.32
UK	0.05	0.09	0.11	0.10	0.19	0.17
EU27	0.07	0.09	0.12	0.11	0.18	0.15

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in household spending

Household spending increases for all Member States in all scenarios in 2020, although in most cases the impact is fairly small. The positive outcomes are brought about by the increased economic activity and multiplier effects that the additional investment and implied employment (see below) creates. There are no direct effects on household spending in these scenarios.

It is worth noting that the impact on household spending is fairly similar across all scenarios for each respective country. This suggests that the level of investment, the timing of it and the share of it that is publicly funded, does not affect to a great extent the increase in household spending that any investment creates.

TABLE 7.27: IMPACT ON HOUSEHOLD SPENDING, 2020

	CS1	CS2	CS3	CS4	CS5	CS6
Austria	0.01	0.01	0.04	0.01	0.05	0.01
Belgium	0.05	0.07	0.08	0.09	0.11	0.14
Bulgaria	0.01	0.01	0.03	0.02	0.03	0.01
Cyprus	0.01	0.02	0.01	0.01	0.03	0.04
Czech Republic	0.02	0.03	0.02	0.04	0.03	0.04
Denmark	0.00	0.00	0.02	0.01	0.03	0.01
Estonia	0.06	0.08	0.08	0.09	0.12	0.14
Finland	0.03	0.04	0.04	0.04	0.05	0.05
France	0.01	0.01	0.01	0.02	0.00	0.01
Germany	0.03	0.04	0.05	0.05	0.06	0.07
Greece	0.04	0.05	0.09	0.07	0.11	0.09
Hungary	0.09	0.12	0.16	0.15	0.21	0.20
Ireland	0.02	0.03	0.04	0.04	0.06	0.05
Italy	0.01	0.01	0.02	0.02	0.02	0.02
Latvia	0.37	0.46	0.51	0.58	0.63	0.72
Lithuania	0.50	0.63	0.90	0.78	1.16	1.00
Luxembourg	0.02	0.02	0.04	0.03	0.05	0.03
Malta	0.15	0.17	0.37	0.32	0.41	0.35
Netherlands	0.02	0.02	0.10	0.05	0.12	0.05
Poland	0.04	0.04	0.06	0.06	0.07	0.07
Portugal	0.02	0.03	0.04	0.04	0.06	0.05
Romania	0.05	0.06	0.07	0.08	0.08	0.09
Slovakia	0.04	0.05	0.04	0.06	0.04	0.07
Slovenia	0.04	0.04	0.07	0.08	0.08	0.08
Spain	0.00	-0.01	0.03	0.00	0.04	-0.01
Sweden	0.15	0.18	0.19	0.18	0.24	0.23
UK	0.01	0.01	0.03	0.02	0.06	0.03
EU27	0.02	0.03	0.04	0.04	0.06	0.05

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in employment

Employment is positively affected by the additional investment, both directly and indirectly. Direct effects come from the extra demand the investment will place on sectors directly involved in the production of new electricity and gas infrastructures and CCS technologies, such as construction and business services. These sectors may see their capacities stretched and will increase employment levels as a result. This increased employment leads to further indirect increases in employment since incomes and household spending are boosted, and consumer sectors such as retail increase staffing levels to satisfy demand.

As a general rule, the higher the level of investment, the greater its impact on employment, although the effects can be lagged.In some countries the timing of investment in CS3 and CS5 (in which three-quarters of the electricity investment occurs in 2015-2020), means that the impact on employment is larger in 2020 compared to other scenarios (even if they have greater total levels of investment).

TABLE 7.28: IMPACT ON EMPLOYMENT, 2020

	CS1	CS2	CS3	CS4	CS5	CS6
Austria	0.01	0.01	0.04	0.02	0.04	0.01
Belgium	0.01	0.01	0.02	0.02	0.02	0.03
Bulgaria	0.11	0.14	0.15	0.15	0.18	0.21
Cyprus	0.04	0.12	0.04	0.04	0.15	0.20
Czech Republic	0.08	0.09	0.11	0.13	0.13	0.15
Denmark	0.01	0.02	0.03	0.02	0.05	0.03
Estonia	0.10	0.15	0.17	0.16	0.27	0.26
Finland	0.09	0.11	0.10	0.12	0.13	0.16
France	0.01	0.01	0.02	0.02	0.03	0.02
Germany	0.04	0.05	0.05	0.06	0.07	0.08
Greece	0.06	0.08	0.15	0.10	0.19	0.13
Hungary	0.04	0.05	0.07	0.07	0.09	0.09
Ireland	0.12	0.15	0.17	0.20	0.22	0.26
Italy	0.01	0.01	0.02	0.02	0.02	0.02
Latvia	0.30	0.37	0.44	0.47	0.55	0.59
Lithuania	0.35	0.44	0.57	0.54	0.74	0.70
Luxembourg	0.05	0.05	0.09	0.08	0.11	0.09
Malta	1.33	1.49	2.85	2.65	3.20	2.98
Netherlands	0.01	0.01	-0.01	0.02	-0.01	0.02
Poland	0.05	0.06	0.08	0.09	0.10	0.11
Portugal	0.07	0.09	0.14	0.11	0.17	0.15
Romania	0.03	0.03	0.03	0.04	0.04	0.05
Slovakia	0.08	0.10	0.15	0.13	0.17	0.16
Slovenia	0.07	0.07	0.12	0.12	0.13	0.13
Spain	0.00	0.00	0.02	0.00	0.02	-0.01
Sweden	0.08	0.10	0.11	0.10	0.15	0.13
UK	0.03	0.05	0.06	0.06	0.11	0.10
EU27	0.04	0.05	0.06	0.06	0.08	0.08

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in sectoral prices

Similarly to the electricity and gas scenarios, the combined scenarios result in very small changes in inflation and price levels at a national level. Across the EU27 as a whole, prices increase by a small amount in all the scenarios, in the range of 0-0.03%.These numbers are extremely small compared to annual inflation targets that are in the range of 2-3%.

A small increase in output prices in some sectors is expected given the increase in demand the additional investment will directly create for specific sectors. For example, if construction firms have full order books they may choose to raise prices.

Table 7.29 presents the results for some of the sectors with the largest changes in prices. The sectors included in the list are clearly ones that would expect to see boosted demand from either the investment itself (such as mechanical engineering and construction) or from the resulting increase in incomes and household spending (such as food, drink and tobacco and hotels and catering).

TABLE 7.29: SELECTED SECTORAL PRICES, 2020 (EU27)

	CS1	CS2	CS3	CS4	CS5	CS6
Mechanical Engineering	0.28	0.37	0.43	0.43	0.58	0.59
Construction	0.07	0.13	0.05	0.10	0.14	0.21
Textiles, Clothing & Leather	0.08	0.10	0.18	0.12	0.24	0.16
Electronics	0.06	0.09	0.08	0.09	0.12	0.13
Hotels & Catering	0.05	0.08	0.01	0.07	0.03	0.13
Computing Services	0.03	0.05	0.05	0.05	0.08	0.08
Other Business Services	0.04	0.05	0.03	0.06	0.04	0.08
Professional Services	0.03	0.05	0.05	0.05	0.07	0.07
Food, Drink & Tobacco	0.01	0.01	0.01	0.01	0.02	0.02
Total	0.02	0.04	0.01	0.03	0.03	0.06

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in sectoral output

Table 7.30 similarly presents results for output in a selected number of sectors. These sectors see the largest increases in output in most scenarios. Again, many of the sectors would be directly or indirectly involved in the production of new infrastructure, and so their output increases.

TABLE 7.30: SELECTED SECTORAL OUTPUT, 2020 (EU27)

	CS1	CS2	CS3	CS4	CS5	CS6
Construction	0.31	0.43	0.56	0.52	0.81	0.74
Electronics	0.26	0.38	0.40	0.41	0.60	0.63
Mechanical Engineering	0.21	0.32	0.43	0.37	0.65	0.56
Metal Goods	0.13	0.18	0.25	0.21	0.37	0.31
Rubber & Plastics	0.11	0.15	0.21	0.19	0.31	0.27
Wood & Paper	0.10	0.13	0.15	0.16	0.21	0.21
Basic Metals	0.09	0.12	0.15	0.14	0.21	0.21
Computing Services	0.08	0.12	0.15	0.14	0.23	0.21
Other Business Services	0.08	0.11	0.14	0.14	0.19	0.19
Total	0.07	0.09	0.13	0.11	0.18	0.16

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Distributional impacts

The impact on average incomes becomes larger as the scale of the additional investment increases (with the exception of CS5, due to the afore-mentioned timing issues).

However, as prices are unchanged there is virtually no impact on the different income groups, so we can say that the distributional effects are negligible. This is shown in Table 7.31.

TABLE 7.31: DISTRIBUTIONAL EFFECTS, 2020 (EU27)

	CS1	CS2	CS3	CS4	CS5	CS6
All households	0.02	0.03	0.05	0.04	0.06	0.05
First quintile	0.02	0.03	0.04	0.04	0.06	0.05
Second quintile	0.02	0.03	0.05	0.04	0.06	0.06
Third quintile	0.03	0.03	0.05	0.04	0.07	0.06
Fourth quintile	0.02	0.03	0.05	0.04	0.07	0.06
Fifth quintile	0.02	0.03	0.05	0.04	0.06	0.05
Manual workers	0.03	0.03	0.05	0.04	0.07	0.06
Non-manual workers	0.03	0.03	0.05	0.04	0.07	0.06
Self-employed	0.02	0.03	0.04	0.04	0.06	0.05
Unemployed	0.02	0.02	0.03	0.03	0.04	0.04
Retired	0.01	0.02	0.03	0.02	0.04	0.03
Inactive	0.01	0.01	0.02	0.02	0.03	0.02
Densely populated	0.02	0.03	0.05	0.04	0.06	0.05
Sparsely populated	0.02	0.03	0.04	0.04	0.06	0.05

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

TABLE 7.32: CHANGE IN ENERGY DEMAND, 2020 (EU27)

	CS1	CS2	CS3	CS4	CS5	CS6
Power generation	0.01	0.02	0.04	0.02	0.05	0.03
Other energy own use and trans.	0.01	0.02	0.01	0.02	0.02	0.03
Iron & steel	0.04	0.06	0.05	0.06	0.08	0.09
Non-ferrous metals	0.04	0.05	0.06	0.06	0.08	0.09
Chemicals	0.00	0.00	0.01	-0.01	0.01	0.00
Non-metallics	0.03	0.04	0.05	0.05	0.06	0.07
Ore-extraction (non-energy)	0.01	0.01	0.02	0.02	0.02	0.02
Food, drink & tobacco	0.01	0.01	0.02	0.02	0.03	0.02
Textiles, clothing&footwear	0.01	0.02	0.02	0.02	0.03	0.03
Paper & pulp	0.07	0.09	0.10	0.11	0.15	0.15
Engineering	0.03	0.04	0.07	0.05	0.11	0.07
Other industry	0.08	0.10	0.14	0.13	0.18	0.17
Rail transport	0.01	0.01	0.02	0.01	0.03	0.02
Road transport	0.07	0.09	0.12	0.11	0.16	0.15
Air transport	0.03	0.05	0.04	0.05	0.05	0.07
Other transport services	0.01	0.01	0.01	0.01	0.02	0.02
Households	0.01	0.01	0.02	0.01	0.02	0.01
Other final use	0.04	0.05	0.07	0.06	0.10	0.08
Non-energy use	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.03	0.04	0.05	0.05	0.08	0.07

Note(s): Figures are % difference from base case.
Source(s): E3ME, Cambridge Econometrics.

Changes in energy demand and emissions

Energy demand increases across all scenarios, for all fuel users except non-energy use (which is exogenous), as Table 7.32 shows. This is as a direct result of the increased economic activity from both households and firms that has been discussed elsewhere in this section. Again, the effects generally get larger the greater the level of investment, caused by higher levels of demand and economic activity. The largest impact is in 'Other Industry' which includes construction.

The increased economic activity that is both a direct and indirect result of the additional investment also leads to increases in several types of emissions, although this is very small and only assessed partially in E3ME (as explained above).The change in the level of emissions tends to get larger the higher the level of investment. However, it should be noted that these small increases are outweighed by the reduction of emissions that the renewable technologies included in the scenarios create.

7.5 Impact on SMEs

Electricity scenarios

A small or medium sized enterprise (SME) is defined by Eurostat as a firm that employs less than 250 people, or has an annual turnover of less than €50m.Tables 7.33 to 7.35 show the top 20 E3ME sectors based on the share of total industry turnover that is attributed to SMEs. Some sectors are not included in the list due to a lack of data on SMEs within the sector. However, for most of the sectors excluded, such as the public and financial sectors it can be reasonably assumed that they will not be dominated by SMEs. The only two sectors that are excluded that do not fall into this reasonable assumption are agriculture and miscellaneous services, two sectors which are likely to have a large number of SMEs accounting for a large share of industry turnover. However, neither is likely to be particularly affected in the scenarios.

Table 7.33 also shows the impact on sectoral output in ES1 and ES2 for the selected sectors. In all sectors, excluding hotels and catering, there is an increase in output in the electricity scenarios, but it should be noted that these increases are very small. The exception to this is the construction sector, in which output is expected to increase by 0.24%. Despite this, it seems that the changes in output are relatively large for those sectors in which SMEs make up a majority, compared to other sectors (see Table 7.7 for the change in output for all E3ME sectors).

TABLE 7.33: SMEs WITHIN E3ME SECTORS

Sector	Share of Total Industry Turnover Attributed to SMEs (latest available data)	Impact on Sectoral Output, 2020 (EU27)	
		ES1	ES3
Professional services	83.1	0.05	0.05
Construction	78.8	0.25	0.24
Hotels and catering	77.5	0.00	0.00
Metal goods	77.0	0.11	0.11
Distribution	73.9	0.05	0.05
Textiles, clothing and leather	73.1	0.04	0.04
Manufacturing nes	70.8	0.04	0.04
Other mining	63.7	0.01	0.01
Other business services	63.4	0.07	0.07
Land transport	62.9	0.03	0.03
Printing and publishing	61.5	0.02	0.02
Computing services	57.6	0.08	0.07
Rubber and plastics	56.2	0.10	0.10
Non-met. min. products	56.0	0.01	0.01
Wood and paper	54.3	0.07	0.07
Retailing	52.7	0.03	0.02
Water transport	52.1	0.02	0.02
Mechanical engineering	46.3	0.02	0.02
Food, drink and tobacco	45.6	0.01	0.00
Electricaleng.& instruments	36.7	0.03	0.03

Note(s): 1. Some sectors have been excluded due to lack of data. These sectors are: Agriculture, Electricity, Gas supply, Banking & finance, Insurance, Public admin. & defense, Education, Health & social work and Miscellaneous services. 2. The model results are % difference from base case.
Source(s): Structural Business Statistics, Eurostat, E3ME, Cambridge Econometrics

Gas scenarios In the same way that Table 7.33 presented the impact of the electricity scenarios on sectors in which SMEs account for a large share of industry output, Table 7.34 presents the results for the gas scenarios.

Similarly to the electricity scenarios, the changes in output are relatively large compared to other sectors, for those sectors in which SMEs account for a large share of industry output (see Table 7.17 for the change in output for all E3ME sectors). From these figures it would thus appear that the gas infrastructure investment will benefit SMEs in particular. However, SMEs in the construction sector are perhaps not likely to benefit as much as SMEs in other sectors. This is due to the likelihood that sizeable firms will have a bigger chance taking on the construction of the new infrastructure due to its large scale.

TABLE 7.34: SMEs WITHIN E3ME SECTORS

Sector	Share of Total Industry Turnover Attributed to SMEs (latest available data)	Impact on Sectoral Output, 2020 (EU27) GS1	GS2
Professional services	83.1	0.01	0.10
Construction	78.8	0.05	0.09
Hotels and catering	77.5	0.00	0.06
Metal goods	77.0	0.03	0.03
Distribution	73.9	0.01	0.07
Textiles, clothing and leather	73.1	0.01	0.15
Manufacturing nes	70.8	0.01	0.05
Other mining	63.7	0.00	0.00
Other business services	63.4	0.02	0.09
Land transport	62.9	0.01	0.07
Printing and publishing	61.5	0.01	0.06
Computing services	57.6	0.02	0.07
Rubber and plastics	56.2	0.02	0.05
Non-met. min. products	56.0	0.00	0.04
Wood and paper	54.3	0.02	0.08
Retailing	52.7	0.01	0.11
Water transport	52.1	0.00	0.02
Mechanical engineering	46.3	0.04	0.08
Food, drink and tobacco	45.6	0.00	0.05
Electricaleng.& instruments	36.7	0.01	0.07

Note(s): 1. Some sectors have been excluded due to lack of data. These sectors are: Agriculture, Electricity, Gas supply, Banking & finance, Insurance, Public admin. & defense, Education, Health & social work and Miscellaneous services. 2. The model results are % difference from base case.
Source(s): Structural Business Statistics, Eurostat, E3ME, Cambridge Econometrics.

Combined scenarios

Table 7.35 presents the results from two of the combined scenarios for the sectors in which SMEs are particularly important (the pattern between sectors is similar for the other scenarios).Again, the changes in output are relatively large for those sectors in which SMEs account for a large share of industry output.

TABLE 7.35: SMEs WITHIN E3ME SECTORS

Sector	Share of Total Industry Turnover Attributed to SMEs (latest available data)	Impact on Sectoral Output, 2020 (EU27) CS1	CS5
Professional services	83.1	0.05	0.15
Construction	78.8	0.31	0.81
Hotels and catering	77.5	0.01	0.05
Metal goods	77.0	0.13	0.37
Distribution	73.9	0.07	0.18
Textiles, clothing and leather	73.1	0.04	0.09
Manufacturing nes	70.8	0.04	0.12
Other mining	63.7	0.02	0.03
Other business services	63.4	0.08	0.20
Land transport	62.9	0.04	0.11
Printing and publishing	61.5	0.02	0.11
Computing services	57.6	0.08	0.23
Rubber and plastics	56.2	0.11	0.31
Non-met. min. products	56.0	0.02	0.07
Wood and paper	54.3	0.10	0.22
Retailing	52.7	0.04	0.10
Water transport	52.1	0.01	0.03
Mechanical engineering	46.3	0.21	0.65
Food, drink and tobacco	45.6	0.01	0.05
Electricaleng.& instruments	36.7	0.04	0.11

Note(s): 1. Some sectors have been excluded due to lack of data. These sectors are: Agriculture, Electricity, Gas supply, Banking & finance, Insurance, Public admin. & defense, Education, Health & social work and Miscellaneous services. 2. The model results are % difference from base case.
Source(s): Structural Business Statistics, Eurostat, E3ME, Cambridge Econometrics.

It would appear then, that the electricity interconnections and gas infrastructure investment could potentially benefit SMEs in particular.

However, this conclusion assumes that the additional investment would affect all firms in each industry identically. It is reasonable to assume that for the large investment projects that are included in these scenarios it would be the larger firms that benefited as they have the capacity to carry out such large-scale projects.

The conclusion is therefore that there will not be a negative effect on SMEs but, if there is a positive effect, it is likely to be very small.

8 Conclusions

8.1 Introduction

This chapter presents the main conclusions from this report.We start by considering the results from the analysis of infrastructure requirements in the electricity and gas sectors. We then summarise the associated investment costs for these projects.In the next section we summarise the macroeconomic impacts of this additional investment.

8.2 Analysis of electricity infrastructure

Results from the network model

Future pan-European electricity infrastructure requirements will be highly dependent on the geographic dispersion of different generation technologies. The three scenarios evaluated as part of this research reveal different infrastructure (network and generation) investment requirements as summarised in Table 8.1 relative to the current position in 2010.

TABLE 8.1: ELECTRICITY INFRASTRUCTURE CAPEX AND ANNUAL OPERATING COST SUMMARY

Scenario	Offshore wind power network infrastructure (€bn)	Member State interconnection investment (€bn)	Additional generation investment for system reliability
PRIMES 2020	32.8	27.7	17.9
PRIMES 2030	50.4	28.1	41.7
High RES 2030	99.8	61.2	92.8

Increasing deployment of intermittent renewable generation sources will increase investment requirements in the power sector, both in terms of network (transmission) and generation infrastructure. The results demonstrate that network and generation infrastructure requirements increase markedly as the capacity and geographic dispersion of RES is increased in order to facilitate resource sharing and maintain system reliability.

For each of the scenarios modelled, it is necessary to increase the total installed generation capacity beyond that envisaged by an annual energy balance, e.g. PRIMES reference scenario data. There are several potential drivers of this requirement including:

- The assumed increase in peak demand will lead to a requirement for greater generation capacity.
- The need to accommodate the variability/intermittency of some generation technologies, particularly wind and solar sources. In order to ensure adequate electricity supply security, it is necessary to add additional generation to compensate for periods when the output from these variable sources is reduced due to limited solar or wind availability.

Consequently, it is important to recognise the limitations of average annual energy balance approaches when evaluating electricity infrastructure requirements and to ensure that shorter time horizon (hourly) analysis is undertaken to confirm generation adequacy.

Analysis of the investment cost for the PRIMES 2020 reference scenario revealed network infrastructure investment requirements closely aligned with ENTSO-E forecasts as contained in the Ten Year Network Development Plan.

The PRIMES 2030 reference scenario shows a modest increase in network infrastructure investment requirement relative to the 2020 position. This is largely attributable to the relatively small change in renewable generation production during the period (from 32% to 36% of total production). This modest network investment requirement also results from the long asset lives associated with transmission assets and corresponding requirements for TSOs to plan network capacity increases over multiple decades. The PRIMES 2030 investments in generation are more significant on account of continued load growth during the decade which also explains the rise in operating costs.

Considerable additional network and generation infrastructure investment is a feature of the High RES 2030 scenario on account of the increased variability and geographic dispersion of the generation portfolio (output from RES representing 49% of total production), the increased resource sharing of production across Member States and the higher total demand to be satisfied. In this scenario, the network infrastructure investment requirement is substantially greater than that currently contained in ENTSO-E’s 2020 plan. This additional investment is justified by the economic benefit of avoiding the curtailment of renewables.This additional transmission then facilitates the greater sharing of all generation sources enabling variability of wind and demand to be damped and improving system security.Due to the significant increases in production from low marginal cost renewable sources, these infrastructure costs are offset by reduced operating (fuel) costs.

The largest Member States and those with the greatest renewable resource potential incur the greatest infrastructure investment requirements, although the results presented in this study must be used cautiously as they heavily depend on certain simplifying assumptions on the geographical distribution of generation, on costs and on distances to be covered by new transmission infrastructure. Not only do these include the Northern European member states but also France and Spain.Should scenarios materialise which are characterised by increased generation sharing across Member States, it will be important to establish equitable cost allocation and financing arrangements, in addition to streamlining the planning and permitting frameworks. While low levels of regional generation sharing will reduce network infrastructure investment requirements (greater Member State self-sufficiency), the financial implications for the generation sector are likely to be more significant and also accompanied by higher levels of renewable energy curtailment.

Given the increasing potential for demand flexibility due to primary fuel switching to the power sector in future decades (particularly transportation and building heating), it may be possible to mitigate these infrastructure investment costs through increased deployment of demand side response measures. Therefore, the results of this research analysis could be regarded as conservative, ie actual costs could be lower.

8.3 Analysis of gas infrastructure

Demand and supply

There is a large amount of uncertainty about future demand for gas, but increases could be expected both in annual consumption and in peak-day demands, although a combination of the economic crisis and increased renewables penetration has lowered recent projections. The projections from the PRIMES model provide one possible view on the evolution of the demand for natural gas. As most EU member states have relatively-well integrated markets already, the analysis focuses on entry points to the EU from non-EU countries.

The EU's growing demands for natural gas in 2020 could theoretically be met with existing infrastructure (domestic production, pipelines and LNG terminals, with storage used to smooth peak demands), if their load factors were increased to 100%, but in practice this is not possible for operational reasons.

Therefore additional capacity will be required to meet this maximum requirement. Using our assumed average load factors of 80% for pipelines and 60% for LNG terminals, pipelines that are planned would be able to provide this capacity for demands in 2020. Beyond 2020, new LNG terminals would be able to provide the additional required capacity.

New developments in storage and reverse flow infrastructure are also required, although the expected costs of these will be less than for pipelines and LNG terminals.

Investment costs

The cost estimates for new infrastructure in the gas sector are a combination of:

- quoted estimated budgets for pipelines (€19bn)
- estimates for new LNG terminals (€4bn)
- estimates for storage and reverse flow (€2bn)

The total cost for new infrastructure in the gas sector is thus estimated as €25bn by 2030, of which the majority is in new pipelines. The locations for the investments are largely provided by the published plans for infrastructure development and focus on Germany, Austria, Romania and Italy.

We would emphasise that these figures are regarded as minimal. In particular, they do *not* include the expenses that have already been incurred for ongoing projects or the upgrades to address specifically the improvement of national grids. Arbitration has also been carried out to eliminate possible overlaps between projects that are either potentially competitive or are still subject to implementation uncertainties[59]. Our final evaluation has been carried out utilizing only data where investments are fully detailed.

In addition, these estimates do not include intra-EU developments.

8.4 Macroeconomic impacts

The economic impacts of building additional infrastructure were assessed using the E3ME macroeconomic model. The model is described further in Appendix IX; it is an appropriate tool to use because:

- it is a fully-specified economic model based on the national accounting structure
- it has a detailed sectoral disaggregation, including separate sectors for electricity and gas

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[59] e.g. the South Stream project.

- its geographical coverage includes each of the EU’s Member States
- its dynamic and empirical econometric specification makes it appropriate for medium-term assessment.

Summary of results: Investment

A set of scenarios was designed and compared to a base case that was calibrated to the *EU Energy Trends to 2030: Update 2009*[60] publication. The focus of the scenarios was on investment costs, but variants considered alternative funding options and possible impacts on gas prices. The detailed results are presented in Chapter 7 and are summarised in the bullet points below, for the investment impacts in the period up to 2020:

- The investment sums that were used as inputs to the model will have a positive but small effect on GDP, principally as investment itself is a component of GDP.
- However, there will also be secondary ‘multiplier’ impacts through the other components of final demand. For example, it is likely that extra workers will need to be employed to build the new infrastructure and they will in turn spend their additional income, boosting GDP further.
- The countries that benefit the most are the ones where the most investment is expected to take place.Several countries in Central and Eastern Europe stand out as examples due to relatively high investment.
- All sectors will benefit to a certain extent from the additional investment. The ones that benefit the most are the ones that produce investment goods, including mechanical engineering and construction.
- There is only a very small inflationary impact on prices, which is mainly due to capacity constraints in engineering and construction firms.
- The distributional impacts are negligible so in this sense these policies should be considered neither progressive nor regressive.
- Impacts on SMEs are expected to be small, but positive rather than negative.
- There is a small increase in energy use, mainly from the construction sector using additional materials.

The scenarios also considered options in which 5% of the investment costs are met by public funding at a European level. This was compensated by a small increase in direct taxation rates so that the scenarios remained directly ‘revenue neutral’. This was found to have little impact on the macroeconomic outcomes.

Table 8.2 and 8.3 below shows the impacts on GDP and employment across the period 2011-20. As expected, the larger the size of the investment, the greater the impact on these variables. In CS6, the combined scenario with the highest level of investment, GDP increases by €199 bn across this period, compared to the base case. This compares to an increase of just €86 bn for CS1, the scenario with the lowest level of investment. The ranking of scenarios is however, not completely in line with the level of investment. For example, the change in GDP is slightly higher in CS2 than CS3. This is due to the timing of the investment. In CS5 and CS3 a large part of the investment occurs towards the end of the period. Since the effects on GDP and employment can be lagged, the full effects of the investment are not felt by 2020

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[60] EU Energy Trends to 2030: Update 2009 (baseline 2009 and reference scenario 2009). A detailed description of these scenarios and their assumptions is available at http://ec.europa.eu/energy/studies/index_en.htm .

(implying that in these scenarios there would be further benefits for a few years after 2020).

TABLE 8.2: IMPACTS ACROSS 2011-2020, EU27, DIFFERENCE FROM BASE CASE IN 2020

Scenario	GDP, €m (cumulative impact across 2011-2020)	Scenario	Employment, 000s (cumulative impact across 2011-2020)
CS1	86,394	CS1	700
CS2	118,669	CS2	891
CS3	113,905	CS3	854
CS4	139,148	CS4	1109
CS5	159,972	CS5	1101
CS6	199,502	CS6	1474

Note(s): GDP figures are in 2000 constant prices.
Source(s): E3ME, Cambridge Econometrics.

TABLE 8.3: IMPACTS ACROSS 2011-2020, EU27, DIFFERENCE FROM CS1 IN 2020

Scenario	GDP, €m (cumulative impact across 2011-2020)	Scenario	Employment, 000s (cumulative impact across 2011-2020)
CS2	32,275	CS2	191
CS3	27,512	CS3	153
CS4	52,755	CS4	409
CS5	73,578	CS5	401
CS6	113,109	CS6	774

Note(s): GDP figures are in 2000 constant prices.
Source(s): E3ME, Cambridge Econometrics.

Macroeconomic impact from other factors

The macroeconomic modelling largely assumed that the investment had no impact on European energy prices because it was difficult to determine what the movement would be (an increased and smoother supply could result in lower prices, but energy firms may also try to recoup investment costs through higher prices). It is noted that this is an important assumption, because in the scenarios where we allowed gas prices to vary by 10%, the effects on GDP of changing gas prices outweighed those from the additional investment alone.

The final sub-set of scenarios in the gas sector focused on possible outcomes if investment in new infrastructure in the gas sector was not made. Although this assessment is based on a broad range of assumptions and should be considered more research than policy oriented, the results from the exercise suggested that the countries that rely on a single supplier of gas, and therefore could be vulnerable to a disruption in supplies, risked losing a much more substantial share of GDP than that from building additional infrastructure.

9 References

9.1 Overview

This chapter gathers the references from the analyses of electricity and gas infrastructure requirements. All of these references are provided in the relevant report chapters, usually in the form of footnotes, but this chapter provides a consolidated list for reference.

9.2 Electricity infrastructure

Bonneville Power Administration, Northwest Gas Association. *Comparing Pipes & Wires: A capital cost analysis of energy transmission via natural gas pipelines and overhead electric wire lines.*

CESI, IIT, ME, RAMBOLL A/S, 2005. *Energy Infrastructure Costs and Investments between 1996 and 2013 (medium-term) and further to 2023 (long-term) on the Trans-European Energy Network and its Connection to Neighboring Regions.*European Commission (DG TREN), (TREN/04/ADM/S07.38533/ETU/B2-CESI).

European Commission, DG TREN, 2003. *Energy and Transport: Trends to 2030.* Brussels: European Commission, (ISBN 92-894-4444-4).

European Commission, DG TREN, 2008. *Trans-European Networks Energy.EU Energy Networks Policy.*

Greenpeace, 2008.*Electricity output of interconnected offshore wind power: A vision of offshore wind power integration.* Belgium: Greenpeace, (GPI REF JN 035).

ICF Consulting Ltd, 2002.*Unit Costs of constructing new transmission assets at 380 kV within the European Union, Norway and Switzerland*. European Commission (DG TREN), (TREN/CC/03-2002).

Oudalov, A., Reza, M., 2008.*Transport or transmit? Should we transport primary energy resources or transmit them as electricity?*ABB Review,(1/2008).

Ramboll, Mercados, 2008. *TEN - ENERGY Priority: Corridors for Energy Transmission*. European Commission (DG TREN), (753110/).

TradeWind, 2009.*Integrating wind: Developing Europe’s power market for the large scale integration of wind power*.

UCTE, 2009.*System Adequacy Forecast 2009-2020*. Brussels: UTCE.

9.3 Gas infrastructure

Afgan, N. H., 2006. *Natural Gas Supply Alternatives for South East and Central Europe*.Acadamyof Science and Art of Bosnia and Herzegovina.Presentation in Sarajevo.

Cameron, P. D. *LNG: Study on Interoperability of LNG facilities and Interchangeability of Gas and Advice on the Opportunity to set up an Action Plan for the Promotion of LNG Chain Investments ; PART II: Environmental and Sustainability Perspective, Final Report.*Brussels: European Commission (DG TREN).

Carter, P., 2009. *Grain LNG, The UK's Foremost LNG Terminal*. Ofgem LNG Seminar.

CESI, IIT, ME, RAMBOLL A/S, 2005. *Energy Infrastructure Costs and Investments between 1996 and 2013 (medium-term) and further to 2023 (long-term) on the Trans-European Energy Network and its Connection to Neighboring Regions.*European Commission (DG TREN), (TREN/04/ADM/S07.38533/ETU/B2-CESI).

Deshpande, A., Economides, M. J. CNG: An Alternative Technology to LNG for the Transport of Natural Gas. University of Houston.

Economic Recovery: Second batch of 4-billion-euro package goes to 43 pipeline and electricity projects, IP/10/231, Brussels, 4 March 2010.

Ellis, J., (2009). *Delivering Caspian Gas from the Caspian Region to Europe – 'It's coming'*. Baku: RWE Supply & Trading GmbH.

Energy Research Centre of the Netherlands,
Eurogas.*Natural gas Demand & Supply: Long term Outlook to 2030.*

European Commission, 2006.Annex to the report from the commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the regions on the implementation of the guidelines for Trans-European Energy Networks in the period 2002–2004; Pursuant to Article 11 of Decision 1229/2003/EC; {COM(2006) 443 final}.

European Commission, DG TREN, 2008. *European energy and transport trends to 2030 – update 2007*. European Commission, (ISBN 978-92-79-07620-6).

European Commission, DG TREN, 2008. *Study on natural gas storage in the EU, Draft Final Report*.

European Network of Transmission System Operators for Gas (ENTSOG), 2009.*European Ten Year Network Development Plan 2010 – 2019.* Brussels: ENTSOG, (09ENTSOG-02).

Eurostat, 2008.*Statistical Pocket Book, 2009.*Luxembourg: Eurostat.

Federowicz, C., 2008. *Poland & The CEE's Oil & Gas Markets future relations with Russia, ensuring price continuity & encouraging new infrastructure*. Amsterdam: Flame.

GSE Storage Investment Database
GSE. ERDGAS KOHLE 122, Jg. 2006, Heft 11.

GTE+, 2009.*Reverse Flow Study TF, Technical Solutions*. Brussels: GTE+.

Haynes, D., Humphreys, C. Martin, P., Stranks, N., 2004. *Strategic Study of Natural Gas Supply to the Island of Crete for Power Generation: Executive Summary to the Engineering and Economic Assessment*. Advantica.

http://www.ecn.nl/fileadmin/ecn/units/bs/INDES/indes-pc2_paper.pdf

http://www.gie.eu.com/gse/storageprojects/

Jensen, J. T., (2003): The LNG Revolution. *Energy Journal*, Vol. 24, No. 2, pp. 1-45.

Leroy, JM., 2009. *The role of natural gas storage in the changing gas market landscape in the changing gas market landscape.*24th World Gas Conference, Argentina.

Margheri, M., (2006).*Developing new gas infrastructure, inc. LNG requirements and practical experience*.Brussels: CEER Workshop.

MVV Consulting, 2008.*Opportunity to Set up an Action Plan for the Promotion of LNG Chain Investments - Economic, Market, and Financial Point of View, FINAL REPORT*. Brussels: European Commission, DG TREN.

MVV Consulting, 2008.*Study on Interoperability of LNG Facilities and Interchangeability of Gas and Advice on the Opportunity to Set-up an Action Plan for the Promotion of LNG Chain Investments, Final report*. European Commission (DG TREN), (TREN/CC/05-2005).

Ramboll, 2008.*Study on natural gas storage in the EU, Draft Final Report*. European Commission, DG TREN, (853102/1024001).

Ramboll, Mercados, 2008. *TEN - ENERGY Priority: Corridors for Energy Transmission*. European Commission (DG TREN), (753110/).

Sydenham, S., 2008.*LNG Workshop, Centrica LNG*.Centrica.

Umbach, F., 2009.*Future Transport, Future Transport Pipelines and Energy Security; Public Hearing on the Security of Energy Supplies*.Brussels: Committee on Industry, Research and Energy, European Parliament.

Vashakmadze, G., 2009. The White Stream gas transportation project - a project to deliver Caspian gas to the EU. Belgrade: GUEU - White Stream Pipeline Company Ltd.

9.4 Internet references

http://ec.europa.eu/energy/infrastructure/index_en.htm

www.ecn.nl

http://www.entsog.eu/

http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/
www.gie.eu

http://www.hydrocarbons-technology.com/projects/bluestream/

http://www.hydrocarbons-technology.com/projects/negp/

www.igi-poseidon.com

http://www.jamestown.org/regions/turkeytest/single/?no_cache=1&tx_ttnews%5Btt_news%5D=35667&tx_ttnews%5BbackPid%5D=408&cHash=9920ec7099

www.nabucco-pipeline.com

www.nord-stream.com

www.reuters.com/article/idUKGEE5AM1BT20091123