Eurogas Roadmap

eurogas

THE EUROPEAN UNION OF THE NATURAL GAS INDUSTRY

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Contents

Executive Summary

This study by Eurogas sets out to describe what Europe's energy balance might look like in 2050, while achieving an 80% reduction of domestic greenhouse gas emissions (GHGs) in the EU, compared with 1990, as proposed by the European Commission in the "Roadmap for moving to a low-carbon economy in 2050".

The Eurogas Roadmap 2050 is aimed at showing one of the possible pathways to achieve the 80% target by reducing emissions in all energy related sectors. This pathway concerns the EU27 as a whole. National policies and companies' strategies can therefore lead to other low-carbon scenarios in each country. The study acknowledges that the scale of the transformation in the way that Europe's citizens and firms use, distribute and make energy will be significant, if the deep cuts in emissions are to be achieved. It recognises that 2050 is a long way away and that technological and social changes can have profound impacts over such a timeframe.

Eurogas brings a distinctive angle to the forthcoming debate around the Energy Roadmap 2050 that the Commission intends to publish in December 2011:

- We show how natural gas can contribute to reducing greenhouse gas emissions in the short, medium and long term, while, thanks to its flexibility, leaving open plausible technological and policy options to achieve the 2050 targets.
- We examine each sector of energy use in detail to identify the actions which could be undertaken in terms of technology penetration and increasing energy efficiency, fuel substitution, as well as behaviour changes. The combination of these actions enables the reduction of GHG emissions in 2050 compared with 1990 by 71% in the residential and services sector, 83% in industry, 69% in transport and 93% in power generation. In total this achieves an 82% reduction of domestic greenhouse gas emissions, as considered necessary for Europe to make a leading contribution to limiting climate change.

The Eurogas Roadmap shows that realising the potential of natural gas uses and technologies in all sectors is an effective way of achieving greenhouse gas emissions compliant with the European Commission's target. It considers the specific capability of natural gas to act as an important enabler of zero-carbon renewables, and provides a view to 2050 of a system that remains flexible in today's choices and keeps open options for tomorrow.

The forty-year period of the study can be subdivided into two phases. The use of gas is clearly beneficial along the whole way to a sustainable future:

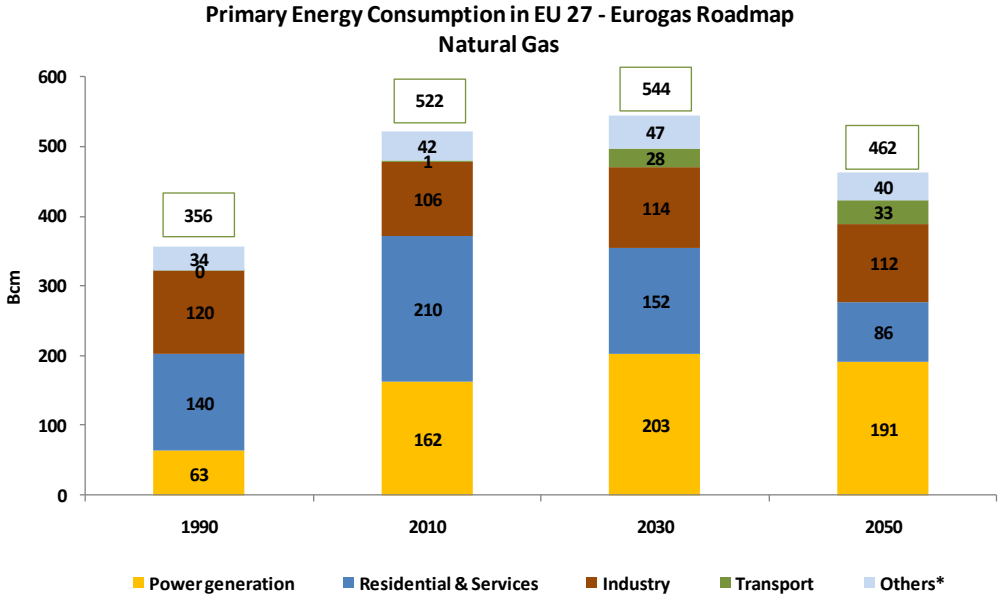
From today to 2030: The high efficiency and low emissions of CO_2 that gas provides, in heating and in power generation, will make a direct and immediate contribution to the reduction of GHG emissions in the EU. Furthermore, the flexibility of gas combines perfectly with the development of renewable sources.

Between 2010 and 2030, the Eurogas Roadmap foresees a key role of natural gas in a low-carbon economy with an increase of the share of natural gas in primary energy

consumption from around 26% in 2010 to 30% in 2030. In this timeframe, the Eurogas Roadmap foresees the sectoral evolution of natural gas as follows:

- In the EU27 residential and services sector, the market share of gas could decrease from around 40% to 35%. Since the total final energy consumption of the sector is expected to decrease, gas sales volumes could drop from 210 bcm in 2010 to 152 bcm in 2030.
- For the industry sector, the market share of gas should remain stable at close to 30% with volumes moving from 106 bcm to 114 bcm.
- Natural gas today has only minor use in transport (1 bcm). In 2030, natural gas should reach a market share of 5% for passenger transport and 13% for freight.
- For power generation, natural gas should see its market share increase from 20% to 25% between 2010 and 2030 (moving from 162 bcm to 203 bcm).

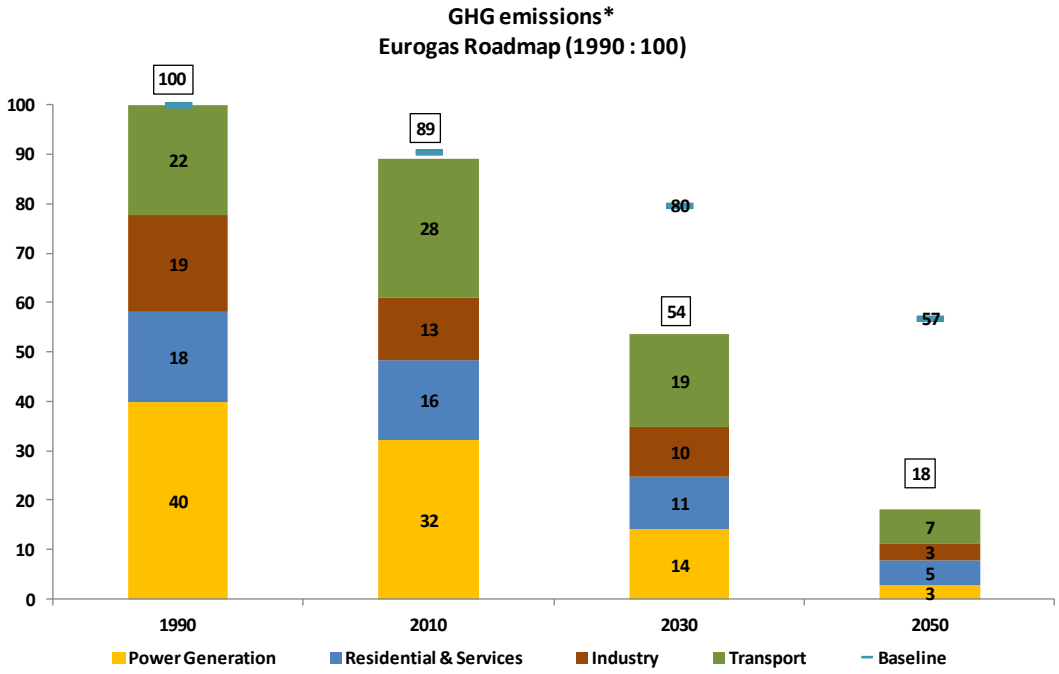
From 2030 to 2050: After 2030, the Roadmap sees the need for the development of natural gas power plants and industrial plants equipped with carbon capture and storage (CCS) technology. These can operate at high load factors while having a low carbon dioxide impact thanks to the application of CCS. There will also remain a need for flexible gas-fired plants to support the necessary large-scale development of variable zero-carbon renewables. Together, these factors imply that gas volumes dedicated to the power sector remain almost stable in the Eurogas Roadmap, with 191 bcm in 2050 compared with 162 bcm in 2010. In the industry sector, CCS deployment will allow natural gas to maintain its market share while significantly contributing to the achievement of the CO_2 emissions reduction target. The final energy consumption of the residential and services sector could decline as efficiency and behaviour change provide a large part of the emissions reduction effort. While in this sector the natural gas market share stands at 23% in 2050, volumes would drop to 86 bcm. As for the transport sector, the natural gas market share should increase between 2030 and 2050, reaching 13% and 33% respectively for passenger and freight transport and representing a volume of 33 bcm in 2050.



*including district heating, raw material and energy branch

Gas therefore opens up options for a European energy future that requires progress to a low-carbon economy. The balance between zero-carbon renewables and CCS in the far distant future is unknown today. By investing in gas, there is an option to go in either direction in the longer term, i.e. to go in whichever direction technology and economics may point at the time. And in doing so, immediate reductions in emissions can be achieved today by substituting gas for higher carbon fuels and by adopting equipment that improves the efficiency with which energy is used.

The European gas industry is strongly committed to working in the direction outlined in this Roadmap. To ensure that natural gas can deliver its potential contribution, the industry needs a stable and predictable policy framework that encourages investment. Alongside the penetration of new technologies, there is a large potential for complementary and supportive development of natural gas and zero-carbon renewables.



*The study addressed energy related CO_2 emissions by sector. Industrial processes and agriculture have not been considered.

This study provides a route that represents a natural strategy for attaining Europe's energy and climate goals. A pragmatic, economical and feasible roadmap for a sustainable energy future has to be based on a large role for natural gas.

As this study proposes a prospective scenario compliant with the implementation of the 2050 GHG targets, it does not pretend to be a forecast exercise such as the Eurogas "*Long term outlook for gas demand and supply 2007-2030*"[1], which is based on a country-by-country approach.

[1] Eurogas brochure "Long Term Outlook for Gas Demand and Supply 2007-2030" published on 6th May 2010 (http://www.eurogas.org/uploaded/Eurogas%20LT%20Outlook%202007-2030_Final_251110.pdf)

I. Context

Background

In the present context of significant economic and energy market uncertainty, the European Commission has initiated several work streams on ways to achieve the political commitment of the EU to reduce greenhouse gas emissions by 80-95% below 1990 levels by 2050. On 8 March 2011 the Commission adopted the Communication **"A Roadmap for moving to a competitive low carbon economy in 2050",** which looks at pathways for the decarbonisation of the economy as a whole. In this framework, DG ENER is preparing an Energy Roadmap 2050 to assess decarbonisation options for the energy sector.

Following the European Commission's work, several organizations have proposed their own roadmaps that describe a decarbonized energy mix in the year 2050. The first set of 2050 scenarios (European Climate Foundation, EURELECTRIC, Greenpeace, European Gas Advocacy Forum) display the same objective: a CO_2 reduction in 2050 of at least 80% from 1990 levels, which is consistent with the domestic reduction target proposed by the Commission in the "Roadmap for moving to a low-carbon economy in 2050". This is achieved by a shift in the pattern of energy use.

The current roadmaps focus on the power sector with less attention to other sectors which will have a major impact, and do not include a detailed analysis of the evolution of energy needs.

The Eurogas Roadmap promotes a shift in the pattern of energy use, introducing behaviour changes and technological changes. The Eurogas analysis therefore offers what we believe is a transparent, constructive and realistic approach to achieving an 80% greenhouse gas reduction in the EU because:

- We look at the possibility of deep carbon reductions in all sectors (not only power generation);
- We emphasize the advantages of natural gas as the best complementary energy for zero-carbon renewables;
- We draw attention to the 'bottom-up' gains in energy efficiency that a new generation of gas-fired technologies can and will bring to home and office heating;
- We identify carbon-reducing benefits in transport (as well as local pollution reduction) that will result from the deployment of a wide range of already marketed natural gas vehicles.

This Roadmap contributes to a perspective based on our industry experience and expertise. Eurogas aims, in particular, to increase awareness of how new energy efficient technologies, low-carbon and zero-carbon energies can work together to contribute to the future energy mix, starting today.

Objective of the study and the scenario developed

The objective of the Eurogas study is to show how large natural gas volumes can contribute to the achievement of the EU targets in a quick, efficient and economically reasonable way:

- Natural gas is low in carbon, so it can provide immediate greenhouse gas savings when substituted for other fuels.

- Natural gas is flexible, so it can be easily combined with zero-carbon renewables, such as wind or solar power and especially biogas.
- Since a large infrastructure is already in place, gas can achieve quicker, much more cost-efficient greenhouse gas reductions than energy that depends on long approval procedures for new infrastructure.

This study has been achieved through a bottom-up approach and is intended to provide an analytic basis allowing in-depth discussion on efficient ways to reach the EU targets. In particular, it aims to achieve the following three objectives:

- To describe a sound picture of how energy needs in all sectors can be met in a way that is consistent with the EU's greenhouse gas objectives;
- To provide a comprehensive, quantified analysis of the role that natural gas can play in the EU energy portfolio and how it can continue to contribute to a balanced energy mix that enables the achievement of the targets;
- To provide a continuum of energy policy choices that will enable milestones to be met in 2030, while leaving open plausible technological and policy options for attaining the 2050 targets.

To achieve these objectives the following steps have been carried out:

- Step 1: Preparation of a detailed historical database and sector breakdown
- Step 2: Elaboration of a Eurogas baseline scenario and comparison with the analysis undertaken by the European Commission on the Primes model
- Step 3: Preparation of the Eurogas roadmap based on sensitivity analyses of key drivers

II. Methodology and approach

Eurogas has adopted the ProspEner tool, developed by the consultant ICE[2] for the study. The combination of the tool and Eurogas industry expertise enabled a prospective analysis of the balance between energy supply and demand from now to 2050.

Eurogas has selected this tool because of certain specific characteristics:

- It is designed to make experts' views quantitatively consistent;
- Data are detailed, comprehensive and transparent;
- It is suitable for creating long-term and very long-term scenarios.

The energy system and the demand and supply balance are modelled based on the detailed analysis of the energy chain. The exercise is based on a bottom-up methodology complemented by sensitivity analyses. The European (EU 27) energy demand is quantified by a comprehensive analysis of the needs for different uses and fuels required to satisfy these needs. This analysis is made for each sector - residential, services, industry and transport - in order to calculate final demand per fuel from 1990 until 2050. The European primary demand is obtained by the prospective analysis of the power generation sector. The energy system is completed by the global assessment and forecast of greenhouse gases for each sector with respect to direct and indirect emissions for each Kyoto gas: CO_2, CH_4, N_2O, HFC, PFC, and SFC shown in CO_2 equivalent.

[2] ICE is a consulting company that offers services to assist the design and implementation of strategies, policies and energy programmes for limiting consumption of energy, renewable energy development and environmental management issues (climate change in particular).

Considering the uncertainties in the costs (investment, operation and fuel) of different technologies that have to be implemented on the demand side and on the supply side over the very long term, the Eurogas roadmap is based on an expert vision of the energy mix for each sector. Energy needs are quantified starting from detailed drivers, such as the renovation rate in the residential sector, energy intensity of different industrial sectors or the mobility needs for the transport sector. These needs are covered by energy mixes which have been built upon the views of Eurogas experts. Although a cost modelling is not part of the ProspEner tool, the costs of different technologies have been taken into account and the energy mixes retained for 2030 and 2050 and reflect the Eurogas views on the competitiveness of future available technology.

III. Baseline and Eurogas Roadmap: Historic trends and main assumptions

1. The baseline

The Eurogas baseline scenario determines the development of the EU energy system under current trends and policies. The scenario presents an industry view based on the historic trends observed in the past 20 years. It is regarded as a benchmark for scenarios of alternative policy approaches or framework conditions.

Our baseline scenario was compared with the study of DG ENER and found to have a consistent basis.

Macro-economic parameters for our baseline include:

- Continued economic growth after the economic crisis has been overcome;
- Population average growth of 0.3% p.a., reaching a peak around 2040 followed by a slow decrease to 2050;
- Sustained environmental awareness among politicians and consumers;
- A growing trend to save energy and to improve energy efficiency;
- Penetration of new technologies.

2. Eurogas Roadmap

This more ambitious roadmap describes how the different sectors can contribute to reaching the 80% greenhouse gas reduction target. It does not follow the historic trends but presents a pathway which takes into account the role of natural gas not only in power generation, but also in the residential and services, industry and transport sectors. It is based on sensitivity analyses, completed by industry expertise.

Beyond the assumptions of the baseline, the Eurogas Roadmap assumes:

- A strong commitment of the EU to reaching its greenhouse gas reduction targets;
- Technological and behaviour changes towards more energy efficiency;
- More renewable energy in combination with gas.

IV. Sector Results

1. Residential and services sector

i. Current situation

In 2010, the 200 million households in the EU27 contributed to 13% of the overall CO_2 emissions in the EU. Until 2050, the number of households is expected to increase due to continued demographic and social change. New construction of housing has slowed down due to the recession. A significant proportion of the housing stock is poorly insulated and in need of refurbishment.

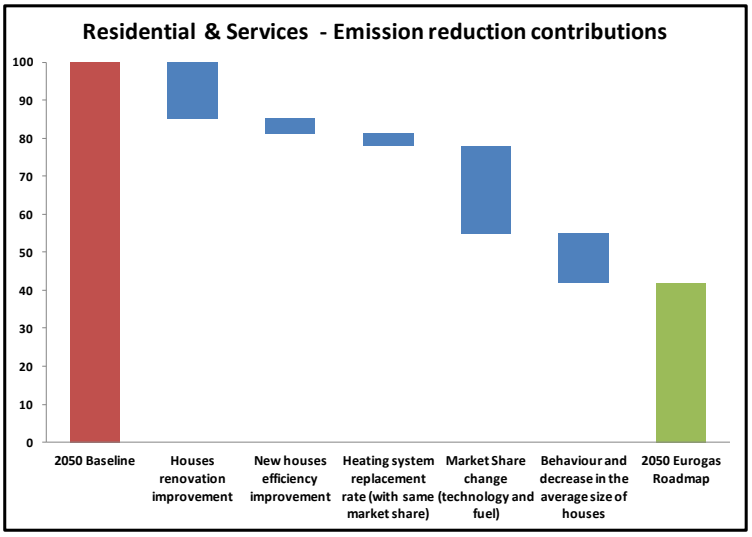
The services sector, which represents around 5.5 billion m², contributes some 5% of the total EU energy CO_2 emissions. The services sector registers about 50% more energy needs than the residential sector at 140kWh/m^2 but offers a higher potential for new constructions guided by cost-efficiency considerations.

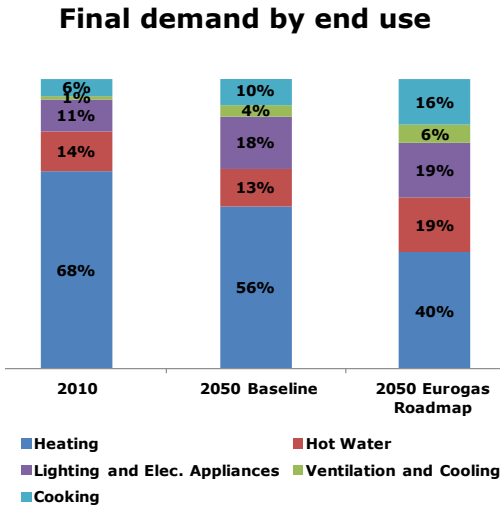
Representing a total of 18% of the EU27 energy CO_2 emissions, the residential and services sector energy needs are mainly driven by heating (68%), followed by hot water (14%), electric appliances, lighting (11%) and "others" representing cooking and cooling (around 7%).

ii. Eurogas Roadmap

The Eurogas baseline scenario for the residential and services sector, which is based on a continuation of current trends and certain technological evolutions, results in a 50% decrease of greenhouse gas emissions in 2050 compared with 1990 levels, mainly due to efficiency improvements in new heating systems.

Eurogas has therefore carried out sensitivity analyses and identified the main parameters that could lead to additional greenhouse gas reductions in this sector. The graph below summarizes the evaluation of the impact on CO_2 reductions of different actions foreseen in the Eurogas Roadmap for the residential and services sector.





- **Renovation**

Renovation is one of the key drivers to CO_2 emissions reductions in this sector. With stronger policy support and financial encouragement, the refurbishment rates could

increase from currently less than 1% to around 3% per year, which would result in significantly higher energy savings of 40% to 50%.

Energy efficiency is an important contributor to the reduction of CO_2 emissions. Until 2050, we assume that the combination of new standards for passive houses and policy incentives will improve the efficiency of the building stock to less than 20 kWh/m² of energy needs per year.

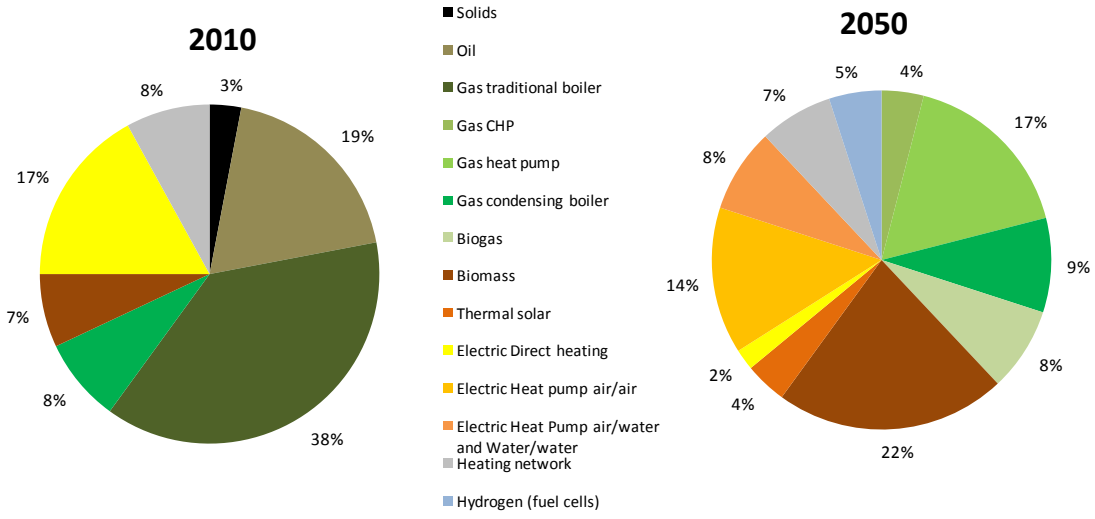
- **Increased energy efficiency of equipment and switch to less pollutant energy sources**

Technological progress and lower costs of new equipment will significantly drive the market towards more efficient equipment and hybrid installations, as presented below.

Faster market penetration of highly efficient heating technologies, such as condensing boilers combined with solar energy, micro-cogeneration, gas and electric heat pumps and ultimately fuel cells will contribute to decreasing CO_2 emissions in the residential and services sector.

Another important element contributing to lower CO_2 emissions is switching to less polluting sources in this sector.

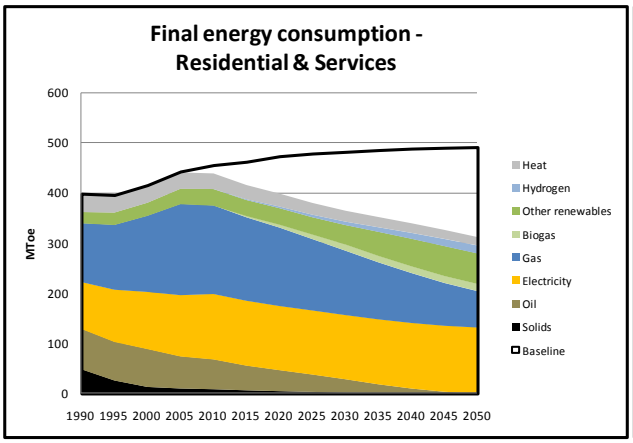
Evolution of equipment market shares in the residential sector in the Eurogas Roadmap:

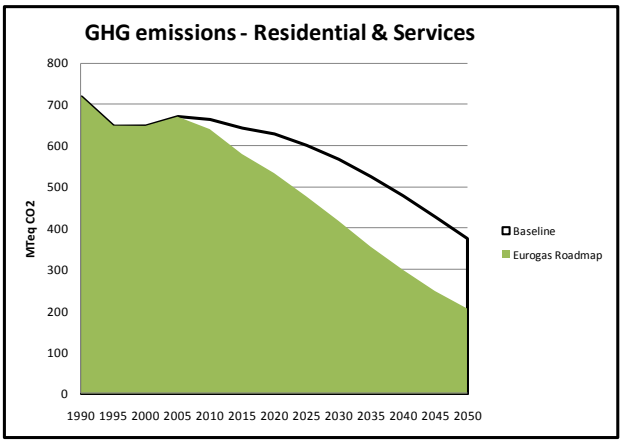


- **Behaviour**

Throughout the study period we do not expect the population of Europe to lower their standards of living. Certain behaviour changes, however, will be observed and required if the EU is determined to achieve its CO_2 emissions reduction targets. We assume that in 2050 people will live and work in spaces which will be on average 10% smaller than today, mainly as a result of increased densification of cities. Despite the increased use of electric appliances until 2050, new equipment performance standards and behaviour efforts should keep the final consumption of electric appliances at current levels. Finally we assume that the average temperature (including day/night differences) of new dwellings would drop by 1°C to 20°C due to better insulated houses and common use of electric smart meters.

Summing up all the efforts described above, the Eurogas Roadmap allows a reduction of 71% in the greenhouse gas emissions of the residential and services sector by 2050.





iii. Scenario preconditions and conclusions

The following preconditions will contribute to the achievements set out in the Eurogas Roadmap:

- Incentives and policy support for the renovation of buildings;
- Research and development in new efficient technologies;
- Incentives to replace existing equipment by promoting more efficient equipment, such as gas heat pumps, gas condensing boilers and hybrid solutions;
- Incentives to use less polluting fuels, such as gas, biogas and biomass;
- Investment in rollout of hybrid technologies (gas and renewables);
- More rational use of existing equipment in dwellings;
- Stricter energy efficiency standards for electric appliances;
- Active awareness campaigns to influence people's behaviour.

Together with stricter standards for energy use and increased CO_2 awareness, natural gas plays an important role in the residential and services sector. Over the past 20 years, industry and consumers have invested massively in installing the required infrastructure for natural gas, which is underlined by the fact of gas being the market leader in this sector.

The quickest and cheapest way to reduce greenhouse gas emissions in this sector is to support and incentivise the renovation of the existing stock by replacing existing gas technologies with improved appliances, such as condensing boilers, gas heat pumps, micro-cogeneration and ultimately fuel cells. The presence of gas in the current building stock is also the most efficient enabler for a higher penetration of renewables in this sector. Renewables and hybrid solutions, such as boilers combined with solar energy, can be more quickly introduced in this sector than changes that require householders to undertake more complex or extensive structural work, such as the installation of ground-based electric heat pumps.

Gas can play a significant role in reducing greenhouse gas emissions in the residential and services sector by increasing efficiency and encouraging behaviour changes and thus reaching 71% lower emissions than in 1990.

2. Industry

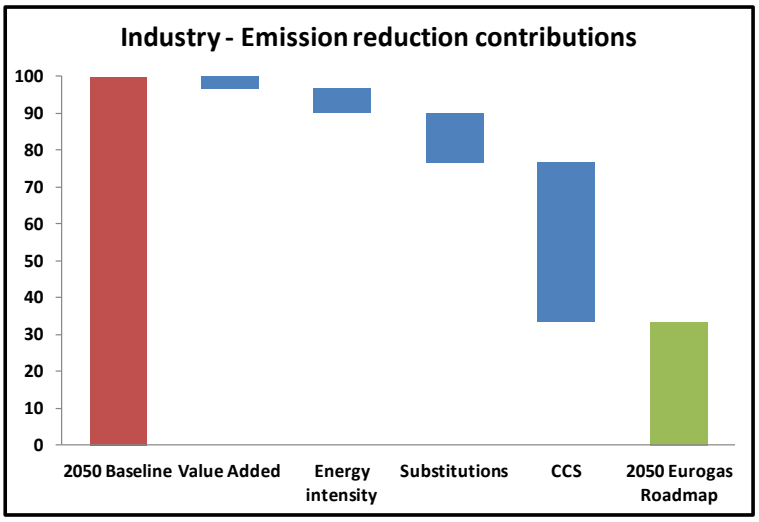
i. Current situation

For the analysis of the industrial sector we have considered nine branches, namely iron and steel, non-Ferrous metals, chemicals, non-metallic minerals, paper and pulp, food, drink and tobacco, engineering, textiles and other industries. This sector contributed around 15% of the total energy related CO_2 emissions in 2010 with significant shares from iron and steel (30%), non-metallic minerals (20%) and chemicals (17%). The industry sector is also the sector that has made a large effort in reducing its greenhouse gas emissions both in absolute terms and in terms of adding value.

European industry is facing strong international competition and therefore continuously has to control its production costs of which an important part is a constant focus on adapting and improving its energy intensity. Given the heterogeneity of the industrial sector, it is very difficult to identify the precise overall CO_2 saving potential. Whether it is the addition of more energy efficient technologies, the substitution of technologies and processes, heat recovery or behaviour choices, the industrial sector tends to adapt more quickly than other sectors since it is directly exposed to price signals. The European industrial sector is amongst the most efficient world-wide and the efforts made over the past decades have resulted in optimal production efficiency. Further improvements in energy intensity can be anticipated, but there is a limit to what can be attained in each branch if deindustrialisation of the European economy is to be avoided.

ii. Eurogas Roadmap

When considering the Eurogas baseline, we arrive at a CO_2 decrease of 49%, which is not sufficient for the target proposed by the Commission. Eurogas has therefore identified the most important parameters that could lead to additional greenhouse gas reductions. These are illustrated below.



- **Substitutions towards natural gas**

Today, natural gas accounts for about one third of final industrial consumption (excluding industrial power plants) and is thus a major source of energy in this market, too. In the medium term, the quickest way to decrease CO_2 emissions in this sector is by promoting further penetration of natural gas, especially in the iron and steel and chemicals sectors.

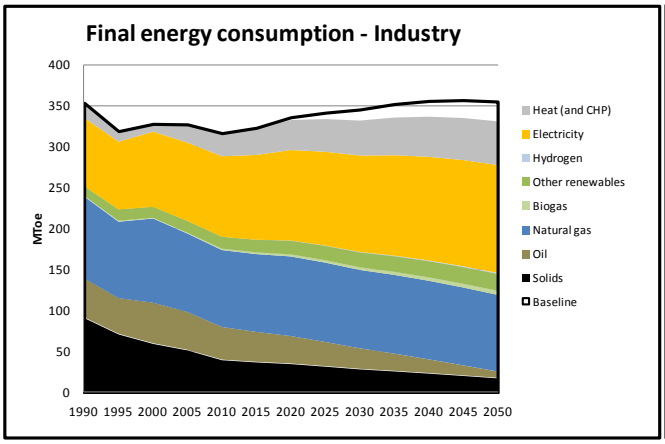
- **Introduction of CCS after 2030**

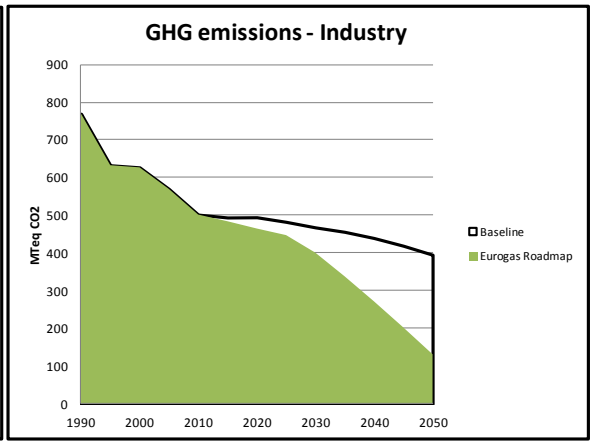
Although CCS technology is still in a research and development stage, we consider that after 2030 it will be possible to install CCS on large industrial plants. Preconditions are the right CO_2 signals, such as an efficient emissions trading system or a carbon tax. In the long term the introduction of CCS can decrease CO_2 emissions by 66% compared with the baseline scenario.

- **Energy intensity**

Reduction of energy intensity plays a role in this sector and can contribute to a drop in CO_2 emissions of at least 7% in 2050, compared with the baseline scenario.

Traditionally, the industrial sector has been very successful in energy conservation. Analysis referring to the input fuel mix shows that one third of the final energy consumption in this sector still involves highly polluting sources. The Eurogas Roadmap simulations lead to the following energy mix, which results in an 83% decrease in CO_2 emissions in 2050, compared with 1990.





- **Scenario preconditions and conclusions**

The following preconditions will contribute to the achievements set out in the Eurogas Roadmap:

- Continuing acknowledgement of the role of industry in the EU economy;
- Consideration of the international context and preservation of the competitiveness of the EU industry;
- Promotion of research and development in CCS for industrial uses;
- Promotion of research and development for hybrid solutions combining gas and renewables;
- Support for heat recovery processes.

The industrial sector is very competitive and therefore, in the medium term and under a well working CO_2 regime, gas will be able to expand its position at the expense of oil and coal. In the future, energy savings will bring more cost-effectiveness and any efforts further to improve the efficiency of the processes with new technologies such as CCS will be very valuable. Heat recovery and significant use of renewables will also contribute to a major reduction of CO_2 emissions in this sector.

3. Transport

i. Current situation

In 2010 the transport sector was responsible for about 30% of overall energy related CO_2 emissions in the EU. Since 1990, transport is the only sector that has seen a significant increase of 25% in greenhouse gas emissions within the EU, a trend that must be turned around if the EU emission reduction targets for 2050 are to be reached.

For the transport sector we analysed the average journey distance, individual mobility, freight needs, transport means, technology and fuel mixes.

ii. Eurogas Roadmap

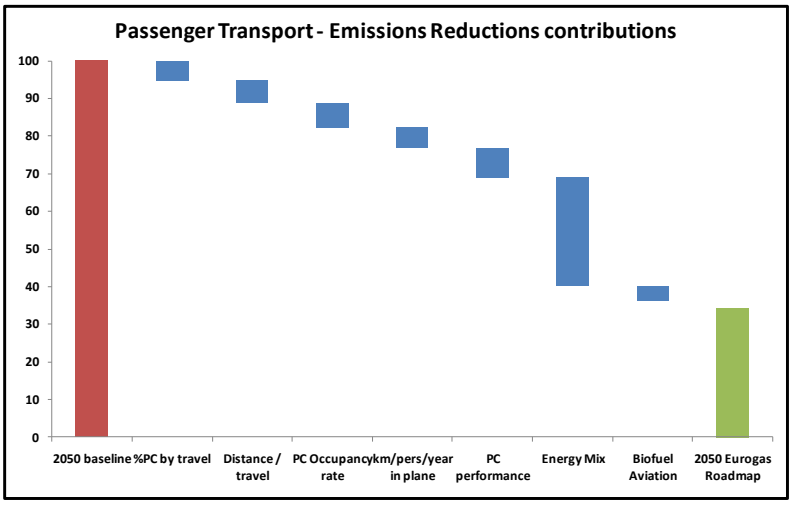
The continuation of the current trends (the baseline) could lead to an increase in emissions of 25% by 2030 and only to a 3% reduction in 2050, compared with 1990. The passenger transport sub-sector would achieve a 17% emissions reduction in 2050 whereas the freight sector would increase its emissions by 31%.

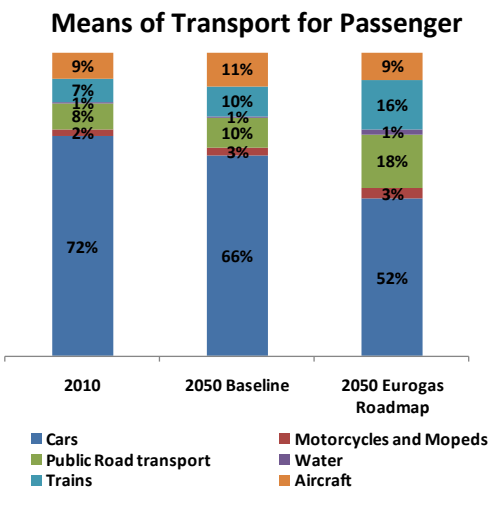
The following sections explain the Eurogas Roadmap assumptions on the actions which could be undertaken to achieve at least a 60% reduction by 2050 compared with 1990, as suggested by the European Commission.

The description of this sector is presented in two separate sections: passenger transport and freight. The assessment of the sensitivity analysis focuses on the increase of energy efficiency as first step, next on changes in mobility behaviour and finally on the substitution of today's fuels wherever it adds value to CO_2 reduction.

ii.1. Passenger transport

The growing population, together with the effect of peri-urbanisation and democratisation of the use of air travel, leads us to assuming an important growth in demand for passenger transport to 2050. The baseline would only result in a 17% reduction in 2050, compared with 1990. Eurogas has therefore identified the main parameters that could lead to additional greenhouse reductions in passenger transport. Today, more than 95% of individual mobility is by fuels based on oil products, mostly gasoline and diesel.





- **Increase in efficiency**

Between 2010 and 2050, the Eurogas Roadmap assumes a 60% efficiency improvement for private cars, resulting from the combination of increasing efforts of manufacturers and the willingness of consumers to buy smaller and more environmentally friendly cars.

- **Behaviour changes in individual mobility**

They are a key factor in reducing greenhouse gas emissions in the transport sector. On the one hand, short distance travel by private car is increasing less in the Eurogas Roadmap than in the baseline, mainly thanks to differences in urbanisation policy.

The Eurogas Roadmap also assumes that the occupancy rate of private cars for short distances could increase with the development of car sharing, a result of behaviour changes triggered by economic considerations, increasing transport needs and policy incentives. This measure would further reduce greenhouse gas emissions.

- **Substitution**

The substitution of gasoline and diesel by natural gas, biomethane and hydrogen for short- and long-distance vehicles and the penetration of electric vehicles for short distances within cities, assumed to be 50% in the Eurogas Roadmap in 2050, are key to lower CO_2 emissions. Natural gas for urban fleet vehicles is the best option today available at large scale to lower CO_2 emissions from public transport. Natural gas in combination with the development of hybrid technologies and at a smaller scale the penetration of hydrogen could lead to a 45% reduction in greenhouse emissions, compared with the Baseline. The introduction of biofuels in the aviation sector, substituting for 20% of kerosene demand, would lead to further reductions.

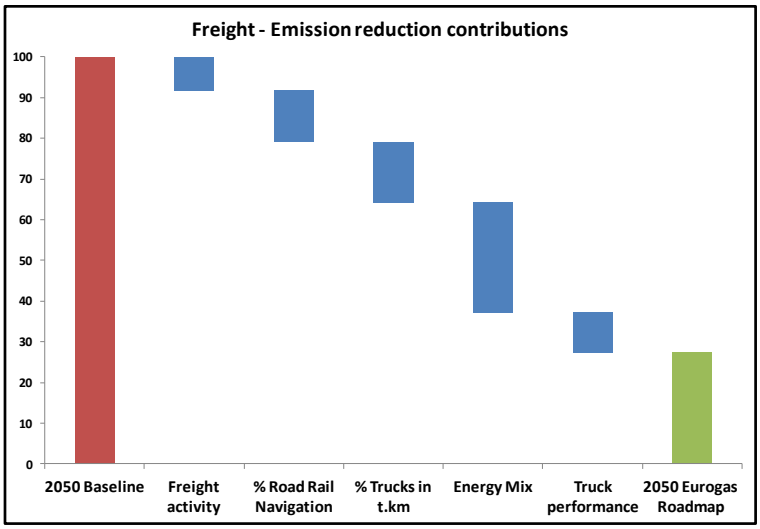
The development of public transport from the countryside to the centre of the cities is assumed to limit the use of private cars for short distances. For long distances the scenario also assumes that high-speed trains are favoured over planes.

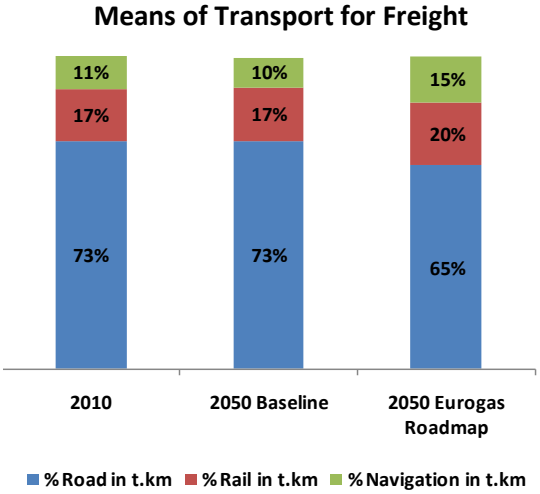
In the Eurogas Roadmap the combination of these measures results in a 24% reduction of greenhouse gas emissions by 2030 and 71% by 2050 for the passenger transport in comparison with 1990.

ii.2. Freight

The level of freight activity is assumed to slow down over the period to 2050 due to better logistic management, such as delivery points at the entrance of the cities. The baseline would nevertheless result in a 31% increase in greenhouse gas emissions in 2050, compared with 1990.

Eurogas therefore identified the main parameters that could lead to additional greenhouse gas reductions in the freight transport sector.





- **Increase in efficiency**

Increasing the energy efficiency of trucks by 50% in 2050 in comparison with 2010 would lead to a gain of around 20% in greenhouse gas emissions compared with the baseline. With a focus on research and development for natural gas driven trucks, including dual-fuel engines, the most efficient engines can reach even more important savings.

- **Behaviour in daily mobility**

Mitigating the use of light duty vehicles for freight, except where it is essential, as in cities, is also an important parameter to reduce fuel consumption and lower greenhouse gas emissions.

- **Substitution**

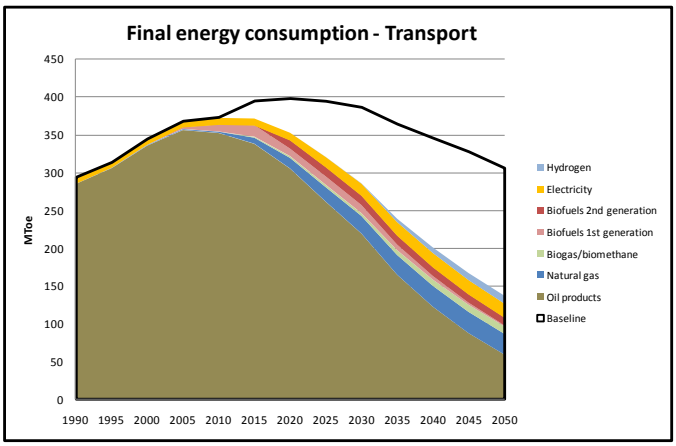
The substitution of gasoline and diesel by natural gas, biomethane, hydrogen, electricity and hybrid applications reduces greenhouse gas emissions by 61% in comparison with the baseline scenario. E–mobility is expected to develop for light duty vehicles. For long distances natural gas is the preferred option to replace diesel for trucks.

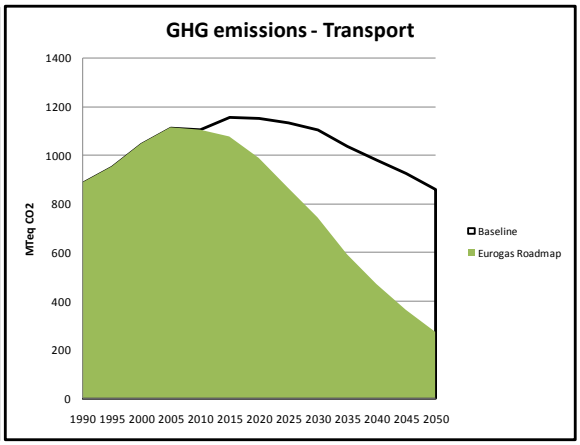
Regarding intermodal transport changes, incentivising the use of rail and waterways for European freight could result in an emissions reduction of 23% in 2050 in comparison with the baseline.

In the Eurogas Roadmap the combination of these measures results in an increase of 3% of greenhouse gas emissions in 2030 and a reduction of 64% by 2050 for the freight activity in comparison with 1990.

In the Eurogas Roadmap final energy consumption in the transport sector decreases by 53% in 2050 in comparison with 1990, mainly due to efficiency improvements of new vehicles, penetration of new technologies and mitigation of mobility needs. In 2050 greenhouse gas emissions are reduced by 69%, compared with 1990, mainly due to the changes introduced in the energy mix but also thanks to technology improvements,

behaviour and intermodal changes. This indicates that there is a potential in this sector that may even exceed the reduction target set in the *Low Carbon Economy* Communication of the European Commission, which was between 54 and 67%.





To decrease emissions in the transport sector, all fuel options will be needed, including natural gas, biogas and biofuels. Electricity and hydrogen will play an important role if technical and infrastructure challenges can be overcome. Beyond fuel substitution, improvements in CO_2 emissions through vehicle efficiency, fuel technology and driving habits are key to achieving greenhouse gas reductions in the transport sector.

iii. Scenario preconditions and conclusions

The following preconditions will contribute to the achievements set out in the Eurogas Roadmap:

- Continuing support for intermodal transport;
- Research and development for vehicle efficiency, hybrid technologies, hydrogen applications, biofuels;
- Promotion of and support for the use of biogas in the transport sector;
- Policy support for gas penetration in the transport sector (especially for the development of infrastructure);
- Strong focus on the reduction of particulates, NO_x and noise in the transport sector;
- Promotion of LNG use for heavy duty vehicles and maritime use;
- Promotion of public transport;
- Urbanism policy for the mitigation of short-mid distance travels;
- Promotion and development of car sharing;
- Promotion of behaviour changes to limit the use of private cars.

Eurogas clearly identifies natural gas as today's best option for fuel substitution, especially for urban fleets and trucks. Moreover, natural gas and biomethane have extremely low emissions of NO_x and other pollutants and emit no particulates, improving air quality and significantly reducing noise and CO_2 emissions. For trucks, liquefied natural gas is already a proven technology that can easily achieve emissions reductions in the freight sector at large scale from today on. Natural gas is a flexible fuel since it can be used in all means of transport (cars, trucks, ships, planes, trains...) for both short and long distances. The penetration of biomethane enables an immediate decrease in the net emission factor of natural gas fuelled vehicles without any technology constraints, using the existing European gas grid.

4. Power Generation

i. Current situation

In 2010, the power sector represented around 35% of total energy related CO_2 emissions. In 2010 gross electricity generation in the EU consisted of nuclear 27%, solids 26%, natural gas 22%, renewables 22% and oil 3%. CHP also plays an important role representing 22% of total electricity supply.

In the Eurogas Roadmap the power sector is modelled in such a way that it satisfies the power needs of the sectors previously described. The main assumptions retained by Eurogas concern:

- The share of different thermal fuels, nuclear and various renewable energy sources;
- The average efficiency of the different technologies.

In the Low-Carbon Economy Roadmap of the European Commission, the objective is to decarbonise the power sector almost fully by 2050. We integrate this objective into the Eurogas Roadmap.

ii. Eurogas Roadmap

In the Eurogas Roadmap, electricity consumption is reduced as a result of different drivers: efficiency, substitutions and behaviour changes, as identified in the other sectors. In the baseline scenario, electricity consumption is expected to increase at an average annual growth rate of 1% between 2010 and 2030, compared with an increase of only 0.4% in the Eurogas Roadmap. Between 2030 and 2050, power consumption registers an annual growth rate of 0.7% in the baseline scenario and of 0.3% in the Eurogas Roadmap.

In terms of primary energy consumption, the role of natural gas in electricity generation is expected to increase significantly between now and 2030, from 20% in 2010 to 25% in 2030. This share is expected to be stable between 2030 and 2050. To comply with the Commission's emission target for 2050, the Eurogas roadmap considers different options in terms of renewables, nuclear power and CCS.

- **Renewables**

The Eurogas Roadmap provides for a significant increase in the contribution from renewables: an increase from 37% in 2030 to 51% in 2050 (vs. an increase from 29% to 37% in the baseline scenario in the same years). With regard to renewables, hydro is expected to remain stable between 2030 and 2050 in both cases. The Eurogas Roadmap anticipates a significant increase in wind generation from 4% in 2010, to 15% in 2030 (vs. 10% in the baseline scenario) and to 19% in 2050 (vs. 15% in the baseline scenario). This assumption involves important investments in system adequacy and balancing, including backup capacity for which natural gas is the most relevant fuel. Should a high renewable scenario materialize, the existing gas infrastructure should be seen as the best option for energy storage and transport. Depending on the utilization rate, this may require appropriate policies to be developed.

Biogas is also an option explored in the Eurogas Roadmap. While the baseline assumes that its share in power generation will not exceed 1% in 2030 and 2050, the Eurogas Roadmap expects it to account for 3% of total power generation in 2030 and for 4% in 2050.

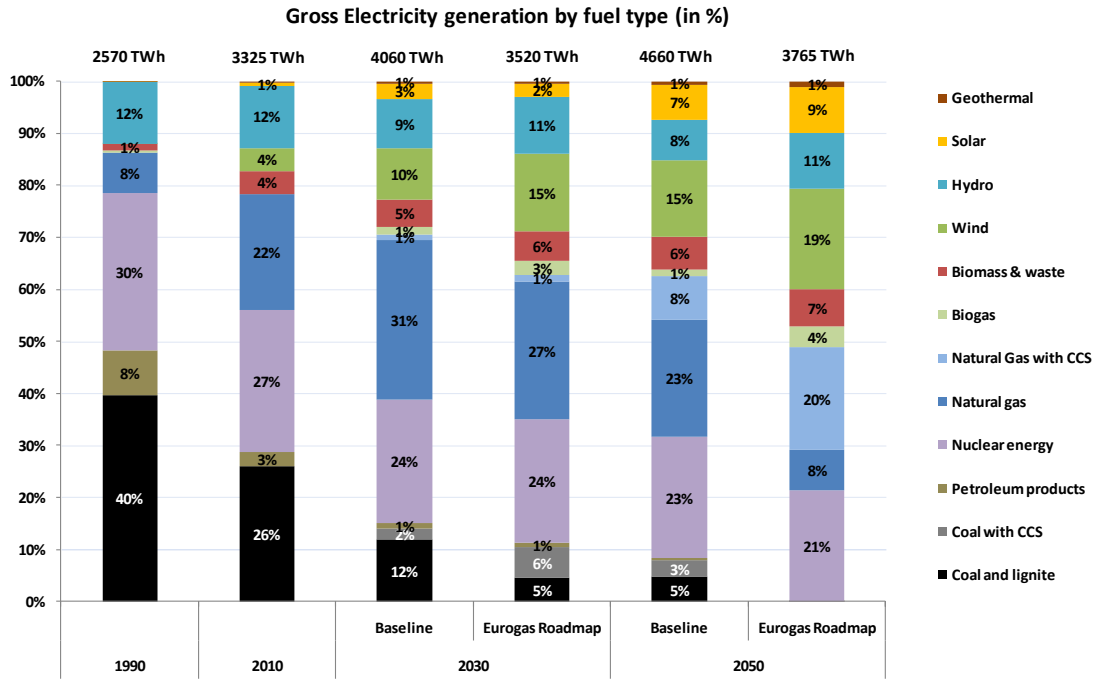
- **Nuclear**

The baseline assumes an almost constant nuclear capacity between 2010 and 2030. The Eurogas Roadmap includes a slightly lower share of nuclear plants in the power mix. This declines from 27% in 2010 to 24% in 2030 and 21% in 2050. These changes reflect political decisions taken in the aftermath of the Fukushima nuclear accident.

- **CCS**

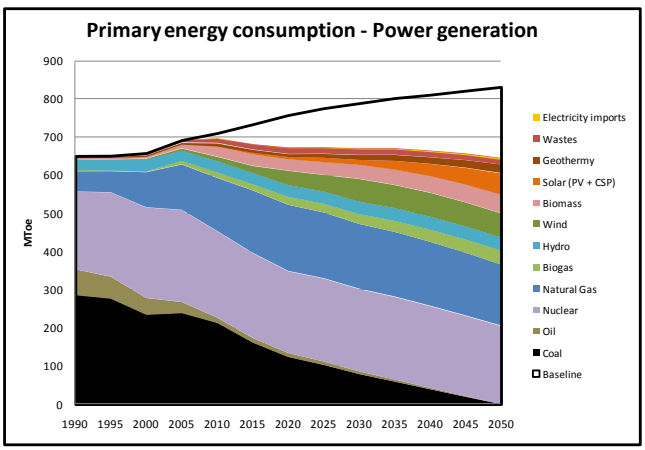
CCS is not expected to develop before 2030, which is the necessary timeframe to reach the maturity of this technology. Although the European Energy Programme for Recovery has approved funds for several demonstration projects, uncertainties related to costs and delays of these projects imply that a commercial development is unlikely before 2030. Still, CCS is a viable and efficient way of achieving large emissions reductions in the long term.

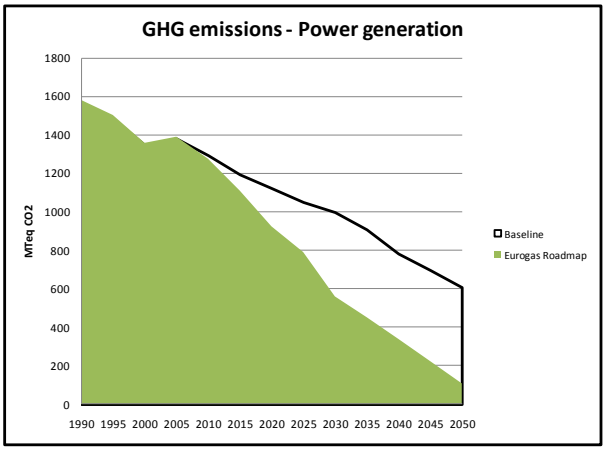
In the Eurogas Roadmap, the share of CCS in connection with natural gas consumption increases from 1% of the power generation in 2030 to 20% in 2050. This implies CO_2 storage requirements below the available capacities estimated in the IEA Technology Roadmap[3].



[3] The IEA Technology Roadmap provides for the capture and storage of 680 Mt of CO_2 by CCS in 2050. The Eurogas Roadmap induces the capture and storage of 280 Mt of CO_2 in 2050.

The assumptions made in the Eurogas Roadmap for the European power mix lead to greenhouse gas emissions reductions of 93% compared with 1990.





iii. Scenario preconditions and conclusions

The following preconditions will contribute to the achievements set out in the Eurogas Roadmap:

- Supporting measures for renewables and incentivized gas-fired backup capacity;
- Supporting measures for CCS, especially by promoting research and development for CCS in combination with gas technologies;
- Increases in power plant efficiency;
- Technological progress in the optimization of electricity system support and dispatch;
- Support for gas as a quick and clean solution to replace coal-fired power generation at the end of their technical life;
- Supporting measures for the development of cogeneration.

Over the considered period the role of natural gas in the power sector will continue to increase. With its flexibility and environmental properties, natural gas offers considerable potential for reducing CO_2 emissions in power generation. The contribution of natural gas lasts through the 2050 pathways without lock-in effects, thus leaving different options open.

In the Eurogas Roadmap, the share of natural gas is expected to increase to 28% between in 2030. Until 2030, natural gas contributes to the quickest emissions reductions. Compared with conventional coal-fired generation, natural gas only generates 40%-50% as much carbon dioxide per kWh. Moreover, combined-cycle gas turbines (CCGTs) are quick and relatively cheap to build and an environmentally attractive option while renewables are being developed to widespread commercial scale.

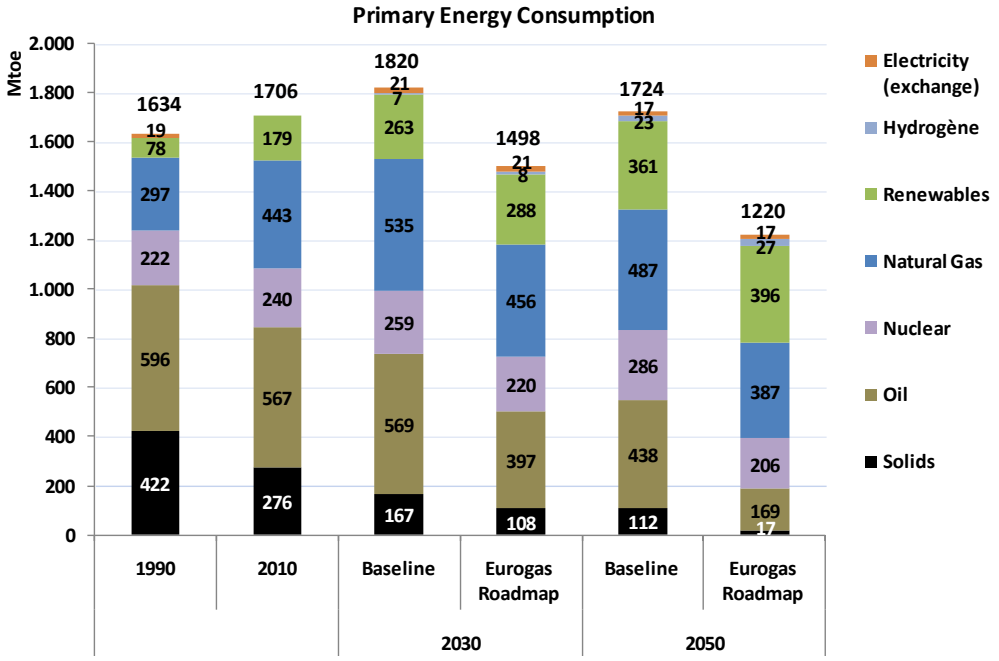
After 2030 and when CCS would have reached commercial maturity, natural gas plants can be adapted for use with CCS technology. Gas power plants with CCS require the storage of only half the CO_2 emitted by coal power plants with CCS. The main advantage of gas is that it can be operated very flexibly and is therefore an ideal backup for intermittent renewable energy. Indeed, between 2030 and 2050, the share of natural gas in electricity generation remains relatively stable, both in the Baseline and Eurogas Roadmap (declining from 32% to 31% and from 28% to 27% respectively) to give room for more use of renewables. Even beyond 2050, natural gas will be indispensible since high load factor plants will hamper further implementation of renewables.

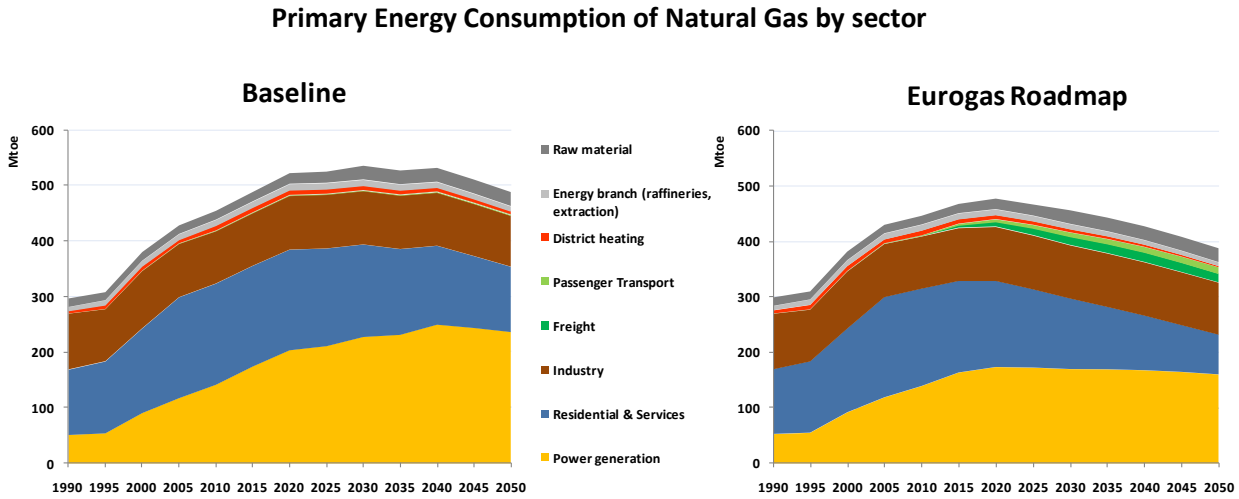
V. Energy consumption

1. Primary Energy Consumption

In the Baseline scenario, European primary energy consumption (PEC) remains stable over the full period, whereas in the Eurogas Roadmap, PEC decreases by 28% in 2050, compared with 2010. Investments to support continuing energy efficiency efforts combined with the climate commitments by the EU will result in a significant improvement in energy efficiency in the EU27.

The growth of renewables also plays a significant role in the reduction of primary energy consumption. There are no conversion losses in the generation of each kWh of wind, solar and hydro power. Accordingly, each kWh from these sources that substitutes in *final consumption* for a kWh generated from other power plants reduces the amount of *primary energy* required.



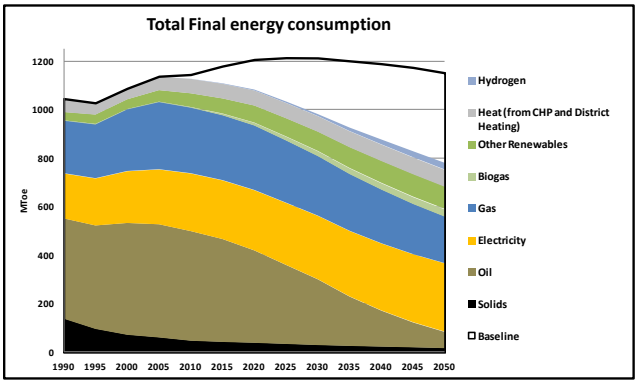


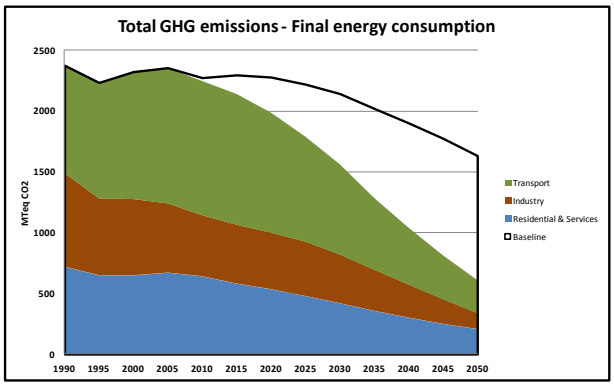
Comparison between Commission targets and Eurogas Roadmap results:

	Contribution of each sector to CO_2 emissions in 2010	**Greenhouse gas reductions compared with 1990**				
		Commission Communication			Eurogas Roadmap	
		2005	2030	2050	2030	2050
Totals		**-7%**	**-40 to -44%**	**-79 to -82%**	**-46%**	**-82%**
Sectors						
Power	35%	-7%	-54 to -68%	-93 to -99%	-65%	-93%
Industry	15%	-20%	-34 to -40%	-83 to -87%	-48%	-83%
Transport (incl. aviation, excl. Maritime)	30%	+30%	+20 to -9%	-54 to 67%	-16%	-69%
Residential and services	18%	-12%	-37 to -53%	-88 to -91%	-42%	-71%

2. Final energy consumption

In the baseline scenario, European final energy consumption (FEC) remains relatively stable over the considered period, whereas in the Eurogas Roadmap, FEC decreases by 30% in 2050, compared with 2010, mainly due to the introduction of new technologies, improved energy efficiency and behaviour changes.





VI. Procurement challenges

The EU's domestic reserves of natural gas in sandstone reservoirs in the Netherlands and on the United Kingdom's Continental Shelf, along with smaller deposits in northern Italy, Germany, Denmark and elsewhere, are in decline.

In some ways, however, EU gas consumers may be 'spoilt for choice' in terms of sourcing and procuring natural gas in the coming decades:

- The EU is located close to 80% of the large world natural gas reserves. Russia, Norway, the African countries, Central Asia and the Middle East have the potential to increase their gas production.
- The supply of natural gas in liquefied form (LNG) has expanded rapidly in recent years, now representing about one fifth of the EU's net imports, supplied from more than ten different countries. This growth in the scale and diversity of LNG supply is likely to continue. In addition to diversification in transport routes and sources, LNG provides European markets with additional flexibility.
- Besides, it is not impossible that potential shale gas reserves in Europe will strengthen its contribution to the total energy mix. An unknown but probably large volume of domestic gas may be available in unexploited shale (as opposed

to traditional sandstone) structures in many parts of Europe. Shale gas has a certain potential for Europe, but significant volumes are not expected to be available before 2030.

On the other hand, although these various supply options exist in principle, Europe is no longer a uniquely attractive market for potential gas suppliers:

- China, India and other major new industrial economies are developing an appetite for natural gas on a scale that will transform their position in the global gas trade. These markets are - already today - heavily competing with European buyers for access to new gas supplies in Central Asia, eastern Siberia and the Middle East.
- The European gas industry recognizes the importance of fostering long-term relationships with major suppliers, transit countries and key partners in the EU, as well as with multilateral organizations and frameworks.

It is the companies' responsibility to conduct commercial relations with producer and transit countries. Institutional dialogue is essential to providing a framework for increased co-operation on a range of issues to achieve necessary political assurances from the countries concerned.

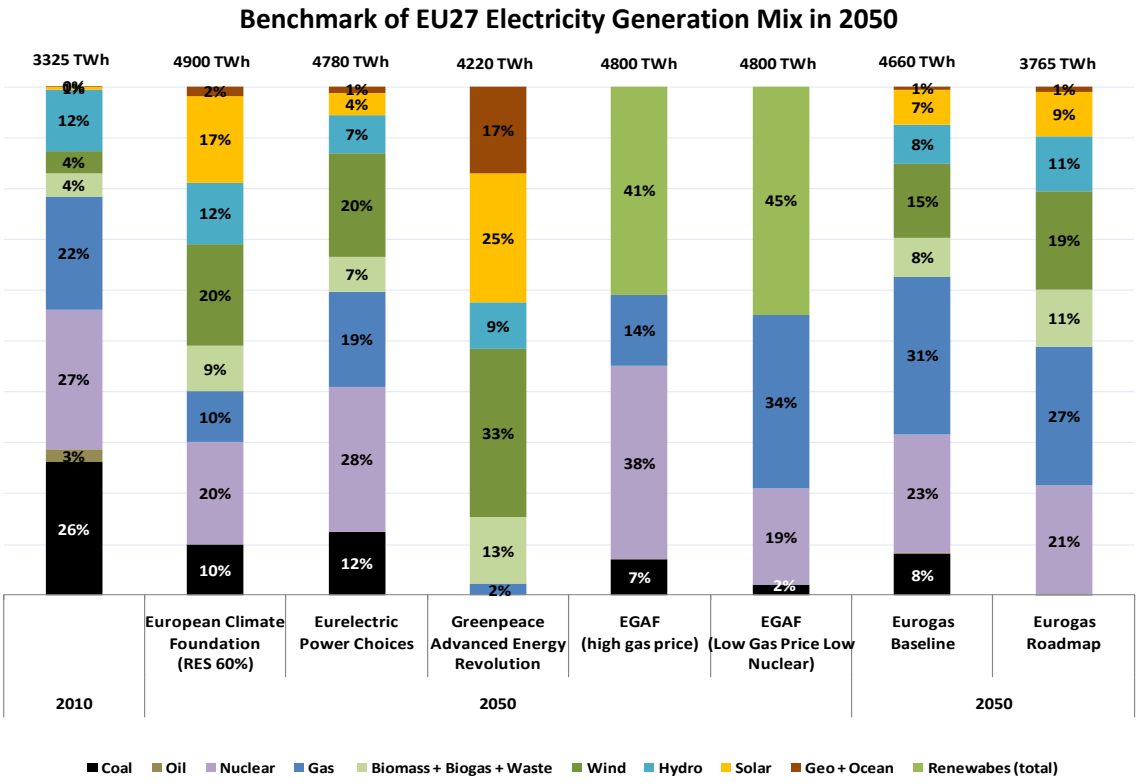
The European gas industry is accustomed to operating in a challenging environment and is committed to satisfying its customers' demand. Nevertheless, to maintain Europe's attractiveness for external gas suppliers, EU policy should clearly recognize the important role of natural gas in a low carbon economy.

VII. Benchmarking

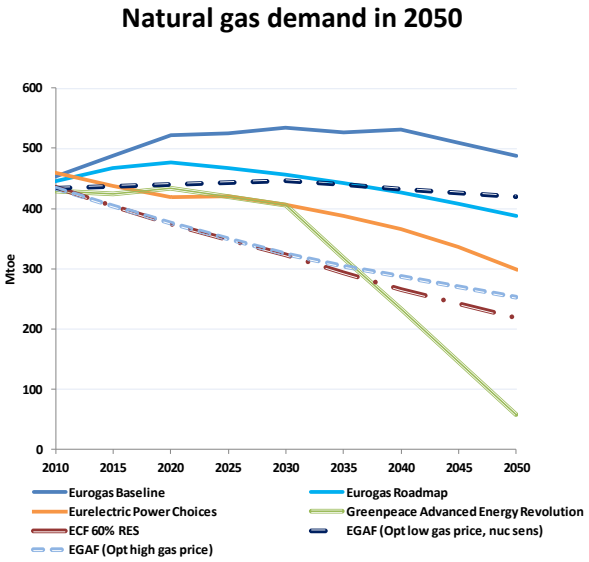
Several organizations have proposed their own roadmaps that describe a decarbonised energy mix in the year 2050. The first set of 2050 scenarios (European Climate Foundation, Eurelectric, Greenpeace, European Gas Advocacy Forum) display the same objective: a CO_2 reduction in 2050 of at least 80% from 1990 levels, consistent with the domestic reduction target laid out in the Commission's Low Carbon Economy Roadmap.

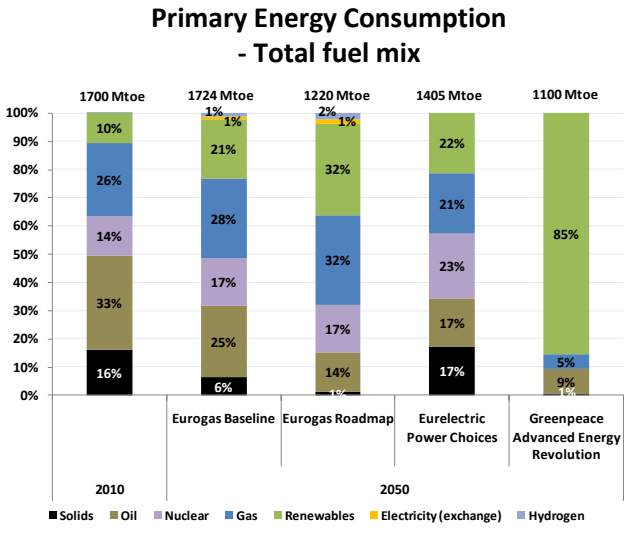
While the existing scenarios to 2050 are based on the extensive use of electricity in the entire economy, by means of a free-carbon energy mix for power generation, the Eurogas Roadmap follows a more balanced approach where greenhouse gas reductions are mainly achieved by the direct use of gas along the energy chain. It is a pragmatic, immediate and energy efficient approach, which recognizes that 2050 is a long way away and that technological and social changes can have profound impacts over such a timeframe. As a consequence, the need for power generation in the Eurogas Roadmap is far below the one proposed by other roadmaps.

A balanced energy mix in electricity generation has been assumed as illustrated in the chart below. When comparing electricity generation in studies available to 2050, we identify the Eurogas Roadmap as proposing an electricity mix combining best available low-carbon energy sources to provide a non-locked-in energy system.



While the Eurogas Roadmap is based on possible energy savings, including through behaviour changes, which could be made all along the energy chain, natural gas volumes decrease together with the total primary energy consumption. However, the share of natural gas in primary energy consumption increases over the considered period from around 26% in 2010 to 30% in 2030 and 32% in 2050, thus recognizing the key role of natural gas in a low carbon economy to 2050.





The Eurogas Roadmap shows that the greenhouse gas reduction objectives can be achieved by means of a more extended use of natural gas, not subject to any radical structural change of the energy economy.

VIII. Conclusions

In conclusion the environmental friendliness and highly efficient technologies in all areas of energy supply give gas a key role in a realistic EU climate policy. The increased use of zero-carbon renewables will be essential for achieving the EU climate policy objectives. Natural gas will complement the penetration of these renewable energies by allowing them to surmount potential system constraints in electricity dispatch and helping with cost and competitiveness constraints at the macroeconomic level. Policy engagements that envision a sustainable role for gas in the energy mix offer a low-risk, high-return route to a low-carbon future in both the medium and very long term, avoiding lock-in effects. The combination of natural gas with zero-carbon renewables (wind, solar, and hydropower) offers a plausible route to the EU's climate objectives.

With CCS in power generation, new highly efficient home appliances and increased use of gas in the transport sector, gas will play an important role in the evolving EU energy mix towards 2050.

Until 2030, the main driver for natural gas will be the power sector, where construction of CCGTs remains the most cost-effective and quickest way to drive down the carbon intensity of electricity supply. However, its environmental qualities and the high energy efficiency of advanced gas technologies now available will also continue to make gas attractive in direct utilisation in homes and businesses, in local CHP plant (including micro-CHP), and offers a significant potential in some Member States in the transport sector too.

Between 2030 and 2050, technological progress and changes in behaviour will further favour a high share of natural gas in the overall energy mix. Gas is one part of the solution next to required changes in consumer behaviour and significant improvements in energy efficiency if a reduction of 80% or more, compared with 1990, in energy related greenhouse gas emissions in the EU are to be achieved by 2050. This implies that the annual natural gas demand in absolute terms, together with all other fuels, would stand at a lower level in 2050 than it does today, but that the share of natural gas in primary energy consumption will increase from 26% in 2010 to 32% in 2050.

A pragmatic view of the path to follow towards a more sustainable energy future should lead policy-makers to reflect more vigorously on the main advantages of natural gas, namely its cleanness, flexibility, cost and availability.

Eurogas
Avenue de Cortenbergh 172 - box 6
B- 1000 Brussels
BELGIUM

Phone:
+32 2 894 48 48

www.eurogas.org

THE EUROPEAN UNION OF THE NATURAL GAS INDUSTRY

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