Does natural gas need a decarbonisation strategy?

The cases of the Netherlands and the UK

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Preface

In 2011 the new buzzword in the European gas industry is "advocacy". The industry has set out on a mission to persuade policy makers at national and European levels that they should give more prominence to the role of gas in their energy balances as the lowest cost way to achieve carbon reduction targets. Many energy companies are expressing the view that gas should be considered a "transition fuel" towards a low carbon economy, and extended this to an argument that gas should even be a considered a "destination fuel" ie a significant part of a low carbon energy balance. But while such terms make great sound bites for corporate speeches, it is not clear whether they have any substance in the absence of concrete commitments to decarbonise the gas sector. This study has been designed to address this issue by asking whether gas needs a decarbonisation strategy to secure its future in European energy balances.

While the industry appears to have convinced itself that it has a great future in a low carbon energy future, Floris van Foreest's work, looking at both national government, EU and academic/NGO energy projections and scenarios, suggests that it has yet to convince other energy industry stakeholders and analysts (whether academic or campaigning). Although many of us believe that the gas industry has a good story to tell in relation to its future in a low carbon economy, its public pronouncements are filled with assumptions that the advantages of gas should be self-evident and, more importantly, have an absence of commitments to decarbonise and little recognition of the importance of such commitments.

Floris van Foreest's work on the role of gas in the transition to lower carbon energy futures is a very important element in the work of the natural gas research programme. With little gas research available from the academic low carbon research community, this study represents an important contribution to the literature and one which we believe will inform the debate both within and outside the gas industry about its longer term future. I am very grateful to Floris for finding time to write this excellent study alongside his other professional commitments.

Jonathan Stern

Oxford, May 2011

Table of Contents

Tables and Figures

Abbreviations

AEBIOM	European Biomass Association
BCM	Billion Cubic Meters
CCC	Committee on Climate Change
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
DECC	Department of Energy and Climate Change
IED	Industrial Emission Directive
IGCC	Integrated Gasification Combined Cycle
LCPD	Large Combustion Plant Directive
LNG	Liquefied Natural Gas
Mtoe	Millions tons of oil equivalent
NGV	Natural Gas Vehicle
SNG	Synthetic Natural Gas

1. Introduction

The proposition that natural gas could be a "transition fuel" has been frequently used in previous years by the gas industry when addressing the future outlook of gas. The main arguments are its (relatively) low emissions compared to other fossil fuels, high efficiency in power generation and the ability to accommodate intermittent renewable capacity. The term transition fuel implies a certain end date, depending on the timeframe of this transition. The proposition of being a "destination fuel" could give natural gas an even stronger foothold in future energy supply. However, are these propositions supported by verifiable developments in the gas market and government policies? In other words, how viable or credible are these claims for a long term role for gas?

In existing energy policy documents of the Dutch and British government, natural gas is neither mentioned as a transition fuel nor as a significant part of the post-transition fuel mix in 2050. The energy and climate policies are mainly focused on meeting the EU 2020 objectives. EU Member States submitted their national renewable action plans in 2010 and support programs have been set up for the development of Carbon Capture and Storage (CCS) technology. The option of equipping gas-fired plants with CCS is hardly discussed. Development of CCS is mainly linked to coal-fired generation. For example, all the six CCS projects that are part of the EU recovery plan are coal-fired and of the 43 announced CCS projects in Europe, only six are based on gas.[2] In the United Kingdom (UK), four CCS projects will be funded as part of the new Energy Act.[3] In the Netherlands, one project has received funding from the EU and the government, and possibly one additional project will follow. So far, all these projects are coal-fired plants. In Norway, the Mongstad project does involve CO_2 capture at a gas-fired power plant, but the government decided in 2010 to delay the decision to finance this project until 2014.

On the other hand, a significant amount of new gas-fired capacity is under construction and proposed in Europe without significant discussion about its carbon footprint. More specifically, in the UK and the Netherlands, where the power markets are already dominated by natural gas, new CCGTs are under construction and more capacity is proposed. Up to 2020, there are no plans for any new gas-fired plants in either country, nor also elsewhere in Europe, to be built with CCS. This development could imply a lock-in of natural gas (and CO_2 emissions) in power generation for the next 2-3 decades.

With respect to the energy supply beyond 2020, European and national roadmaps towards a low-carbon energy supply in 2050[4] have already been developed. Decarbonisation of power generation is a major pillar in these roadmaps. Electrification of heating is another important theme that is part of a so called all-electric future. Especially in natural gas dominated power and heat markets such as the UK and the Netherlands, this could have a significant negative effect on natural gas demand beyond 2020. In general, the future share of natural gas is under pressure and in some cases is even marginalized. However, these roadmaps should be assessed on their merits as they are developed by order of institutes or organizations that pursue different interests in the energy market. For example, governments/EU projections are premised on what needs to happen to meet the climate policy targets and so far they do not

[2] Zero Emission Platform (2010), www.zeroemissionsplatform.eu
[3] Department of Energy and Climate Change, 'Energy Bill Factsheets: Carbon Capture and Storage', 2010
[4]Roadmaps have been published in recent years by among others Shell, IPCC, ECF, Eurelectric and DECC

appear to believe that gas is the best fuel in this respect. In contrast, the gas industry advocates that gas is the best way to meet these targets.[5]

The question posed in this study is whether natural gas needs a decarbonisation strategy to remain a major element in 2050 energy scenarios and climate policies or whether the gas industry can rely on *business as usual* scenarios where the share of natural gas in the energy mix will be maintained without any substantial decarbonisation.

First of all, what would be the scope of such a decarbonisation strategy? Decarbonisation of natural gas could take different forms. Probably the best known route is to capture CO_2 from natural gas that is used for power and heat generation. Another option would be the production of biogas or bio SNG that is upgraded (bio methane) and injected into the natural gas grid for further supply downstream. Technically, using this gas would still cause CO_2 emissions, but it is considered climate-neutral as the CO_2 has been absorbed from the atmosphere by the biomass that is used for producing this gas. If produced on a large scale, it could contribute to extending the long term future of gas in the context of the transition towards a genuine low-carbon energy supply.

According to a study by the Leipzig Institute for Energy and Environment (2007), the European production potential of bio methane in 2020 is sufficient to cover gas demand in the EU and Turkey.[6] However, this theoretical potential includes Russia, Ukraine and Belarus and is based on the assumption that 50% is produced through gasification, which is still in a development phase. The European Biomass Association (AEBIOM) estimates that by 2020, bio methane could account for ~10% (46 bcm) of European gas consumption.[7] Today, the share of biogas is still marginal in Europe. In 2008, 7.5 Mtoe was produced, which is less than 1 % of total primary energy production.[8] The focus in this paper will be on biogas or bio SNG that is upgraded and injected into the grid as a potential low-carbon alternative for natural gas with similar applications. This gas will be defined as "renewable gas".

This paper discusses natural gas developments in the context of the transition to a low-carbon energy supply and describes the decarbonisation options for natural gas in the UK and the Netherlands. The main question that is addressed in this paper is: Beyond 2020, does gas need to demonstrate that it can apply these options to maintain or further enhance its current position? A combination of economic, political and technological factors will determine whether such a demonstration is required. What is the current status of CCS and renewable gas in the UK and the Netherlands and which drivers determine the potential? What is the position of natural gas in energy and climate policies? What would a decarbonisation strategy look like?

In order to set the scene with respect to potential implications of using or not using a decarbonisaton story, this paper discusses two storylines on the future outlook of gas. The storylines are:

- Natural gas is part of a transition, but becomes a sunset fuel post 2025/2030

[5] In a McKinsey study commissioned by the Gas Advocacy Forum, which includes ENI, E.ON, GDF Suez, Shell and Statoil, the claim is made that the EU could meet carbon targets more cheaply with gas.
[6] Leipzig Institute for Energy and Environment, 'Possibilities for a European Biogas strategy' January 2007
[7] European Biomass Association, 'A Biogas roadmap for Europe, September 2009, p.16
[8] EurObserv'ER, The state of renewable energies in Europe, 9th report, Eurostat 2009

- Natural gas could have a claim to be a destination fuel

Chapter 2 provides an overview of the position of natural gas in the UK and the Netherlands up to 2020. CCS and renewable gas as possible decarbonisation options for natural gas are reviewed in chapter 3. In chapter 4, the position of natural gas beyond 2020 is assessed by looking at four 2050 energy scenarios. Furthermore, two storylines with respect to this position are elaborated. In chapter 5, the necessity for and possible contours of a decarbonisation strategy are discussed.

2. Current position of natural gas

The question on the necessity of a decarbonisation strategy for natural gas has to be viewed in the context of actual developments regarding the position of gas in energy supply. First of all, investments by energy companies in gas-based technologies are balanced against investments in other technologies, depending on market conditions. Secondly, the EU and national governments are introducing and updating climate and energy policies and legislation to meet the EU 2020 targets that were adopted by the European Council in 2009.

Supporters of a strong role for natural gas are making the claim that natural gas is a transition fuel towards a low-carbon energy supply. The arguments behind this claim are built on the economic, environmental and energy merits of natural gas compared to other fossil fuels. However, to what extent is this supported by reality in terms of market and policy developments? This chapter discusses the position of natural gas in the energy mix today and towards 2020 in the EU, the UK and the Netherlands.

2.1 EU

2.1.1 Policy framework

In 2009, the European Council adopted the climate and energy legislative package to meet the earlier defined targets for 2020.[9] In addition, the Council has made a long term commitment to the decarbonisation path with a target for the EU and other industrialized countries of 80-95% emission reduction by 2050.[10] However, in its recent energy review, the European Commission stated that with the current strategy, it is unlikely to achieve all the 2020 targets and that it is inadequate to meet the longer term ambitions.[11] Therefore, the Commission proposes a new strategy to meet the 2020 objectives. Proposals are expected to be presented in the coming in 2011 and 2012. Furthermore, it has developed an energy roadmap 2050 that consists of different scenarios to achieve the long term decarbonisation goals. This roadmap, which will also be a political document, could have a serious impact on the long term outlook of natural gas in Europe. This will be further discussed in chapter 3.

The climate and energy package contains legally binding directives that will have impacts on the position of gas in the short term and will more generally be a driver for investments in the coming decade. Before June 2010, each Member States had to submit its national renewable action plan[12] consisting of a detailed roadmap of how to reach the legally binding targets for the share of renewables in final energy consumption. For the UK, this share is 15%, which implies a 30% share of renewable energy in electricity production. The Netherlands has an overall target of 14% and 37% for power generation. The integration of large scale renewable energy projects (mainly wind) will have consequences for natural gas, especially in power generation.

[9] Reduction in greenhouse gas emissions to 20% below 1990 levels, 30% in the context of a global agreement on climate; 20% share of renewables in the final energy consumption; reduction in primary energy use to 20% below the baseline projection for 2020.

[10] European Commission, Communication to the European Parliament, 'Energy 2020, A strategy for competitive, sustainable and secure energy', Brussels, November 2010

[11] Ibid. p.3

[12] Article 4 of the renewable energy Directive (2009/28/EC)

Secondly, the legal framework for CO_2 capture and storage (CCS) technology was also created. The CCS Directive is mainly focused on managing risks related to storage of CO_2. Through this Directive, CCS has become a central element in EU climate and energy policy.[13]

For example, CCS demonstration projects have been included in the European Energy Programme for Recovery and the NER300.[14] So far, these projects concern mainly coal-fired power plants.
Aside from the fact that the longer term position of coal is more or less included through the CCS Directive, nuclear and wind as other mainstream power generation technologies, are also part of the EU energy strategy. Natural gas on the other hand, even as a transition or bridging fuel, is absent in the policy documents that address the transition to a low-carbon energy supply.

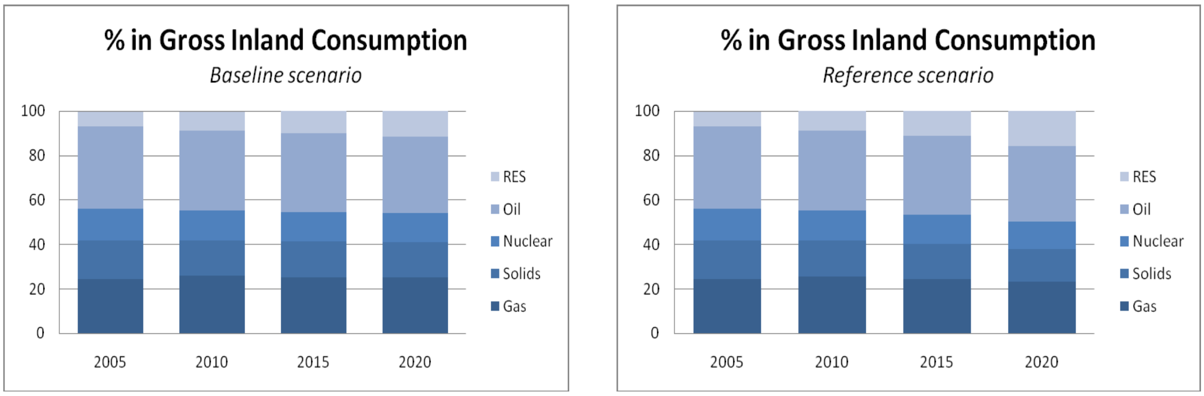
2.1.2 Position of gas

Although natural gas is absent in policy documents, especially climate policy documents, it has a strong position in current European energy balances. In 2008, gas consumption was 260.5 Mtoe, which was 22% of total final energy consumption.[15] Due to the economic crisis, gas consumption dropped by 10% in the first half of 2009 compared to H1 2008.[16] However, by the end of 2009 and in the first quarter of 2010, consumption started to pick up.[17] In 2010, gas demand increased by 7.3% compared to 2009 because of the relatively cold winter period[18] and possibly and, to a lesser extent, by signs of economic recovery. In the electricity sector, the amount of gas-fired power generation by gas has significantly increased since 2000. In 2008, 775 TWh was produced with gas, compared to 480 TWh in 2000; an increase of approximately 60%.[19] The share of gas in total power generation was 23% in 2008, compared with 16% in 2000.

There are different scenarios that show the relative position of gas towards 2020. In its update report of energy trends to 2030, the Directorate-General for Energy provides two scenarios; a baseline and a reference scenario (Figure 2.1).[20] The latter assumes that the two binding targets for 2020 - the 20% share for renewable energy sources (RES) in the gross final energy consumption, and 20% GHG reductions - will be achieved. The baseline scenario uses current trends and policies up to April 2009.

[13] Directive on the Geological Storage of Carbon Dioxide (2009/31/EC).
[14] European Commission, Energy 2020, November 2010. NER300 is a financing instrument managed jointly by the European Commission, European Investment Bank and Member States and contains the provision to set aside 300 million emission allowances held in the New Entrants Reserve (NER) of the EU Emissions Trading System (ETS), to subsidize innovative renewable energy technology and carbon capture and storage (CCS).
[15] EUROSTAT. Consulted website on 15 November 2010.
http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/main_tables
[16] European Commission, 'State of play in the EU energy policy', SEC(2010) 1346 final, 10/11/2010
[17] Honoré, A., 'Economic recession and natural gas demand in Europe: what happened in 2008-2010?', Oxford Institute for Energy Studies, January 2011. It concerns gas demand in OECD Europe.
[18] Ibid., p.26
[19] EUROSTAT, energy, main tables, 15 November 2010.
[20] Directorate-General for Energy, 'EU Energy Trends to 2030, update 2009', Publications Office of the European Union, August 2010.

Figure 1: % natural gas in EU gross inland consumption 2005-2020, baseline and reference scenario



Source: DG TREN (2010) EU Energy Trends to 2030, p. 66, 124

The projections in both scenarios do not show large differences. Only the share of RES is significantly larger in the reference scenario, which is logical considering the assumption of meeting the 20% RES objective. The implication of this seems to be equally shared among the conventional sources. The gas share decreases by 2.5% from 2010 to 2020 in both scenarios.

The share of natural gas in power generation is 22.8% in 2020 in the baseline scenario and 19.5 % in the reference scenario.[21] However, the share of natural gas in fossil fuel-based generation increases significantly in both scenarios, as a result of the phase out of large coal-fired plants.[22] This share is obviously also sensitive to fuel price developments. Rising oil and gas prices will most likely have a downward effect on gas demand in power generation, at least for the coming decade where conventional coal-fired generation will still form a substantial part of total power generation.

Whereas in the baseline scenario, the capacity of gas power plants rises steadily over the time period, in the reference scenario the increase is slower up to 2020 and faster thereafter. Most new power plants will be natural gas-fired using the gas turbine combined cycle technology (CCGT). Finally, in both scenarios, with a share of almost 20% in electricity production in 2020, the role of CHP in electricity production becomes more important.[23]

According to the new policies scenario[24] in the IEA's World Energy Outlook 2010, demand for gas in the EU will increase by 4% between 2008 and 2020.[25] The main driver for this increase is power generation. Electricity produced from gas is estimated to increase by 8.5% in this same timeframe. In the current policy scenario, gas demand increases by 5.7%. However, in the case where an energy pathway is implemented that aims to limit average temperature increase to 2°C (the 450 scenario), gas demand will decrease by 3.6% from 440 Mtoe in 2008 to 424 Mtoe in 2010.

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[21] DG TREN, EU energy trends to 2030, Update 2009, Publications Office of the European Union, August 2010, p. 27, 42.
[22] Ibid., p. 29, 43
[23] Ibid., p. 29, 44
[24] This is the central scenario in WEO-2010 and assumes cautious implementation of recently announced commitments & plans, even if yet to be formally adopted
[25] International Energy Agency, 'World Energy Outlook 2010, Tables for scenario projections', Paris, November 2010

On a national level, other main gas markets in the EU aside from the Netherlands and the UK, such as Germany and Spain, show different growth levels. In Germany, gas demand is estimated to marginally increase towards 2020.[26] This is driven by power generation. Spain on the other hand shows a more promising outlook for natural gas. Demand is estimated to increase by approximately 13bcm in the period 2008-2020, boosted mainly by increasing electricity demand in combination with additional gas-fired capacity. It should be noted however that government projections are often worked out "back to front", to show longer term policy objectives being met, instead of extrapolating current trends into the future.

2.2 United Kingdom

2.2.1 Policy framework

With the Energy Acts of 2008 and 2010 and the Climate Change Act of 2008, the UK government has established a legal framework that is required for meeting the climate objectives. The government has set a CO_2 reduction target of 34% by 2020. To meet this target, three legally binding carbon budget periods have been defined. They run from 2008-12, 2013-17 and 2018-22.[27] The fourth carbon budget, covering the period 2023-2027, must be set by 30 June 2011.[28] In 2009, the Department of Energy and Climate Change (DECC) published the Low Carbon Transition Plan, which specifies the different areas and measures to meet the 2020 targets.[29] Creating a framework for the development of CCS, the National Renewable Energy Action Plan, which followed the EU Renewable Energy Directive, and energy efficiency are prominent elements in this plan. The CCS framework aims to provide an incentive mechanism that supports four commercial-scale demonstration projects. Initially, these projects concern coal-fired power stations, but there has been a discussion recently about also including gas with CCS. Developments around CCS will be further discussed in chapter 3.

Beyond 2020, the government has set a target of 80% reduction by 2050. In 2010 DECC presented the 2050 Pathways Analysis in which different scenarios are developed to meet this target.[30] Decarbonisation of electricity and heat production is a main pillar in all the scenarios. In the coming decade the government aims to make important steps through stimulation of CCS technology, creating the right framework for new nuclear capacity and realizing large scale wind energy projects. This could have serious implications for the role of natural gas. According to DECC, the long term outlook of natural gas is closely related to the viability of CCS.[31]

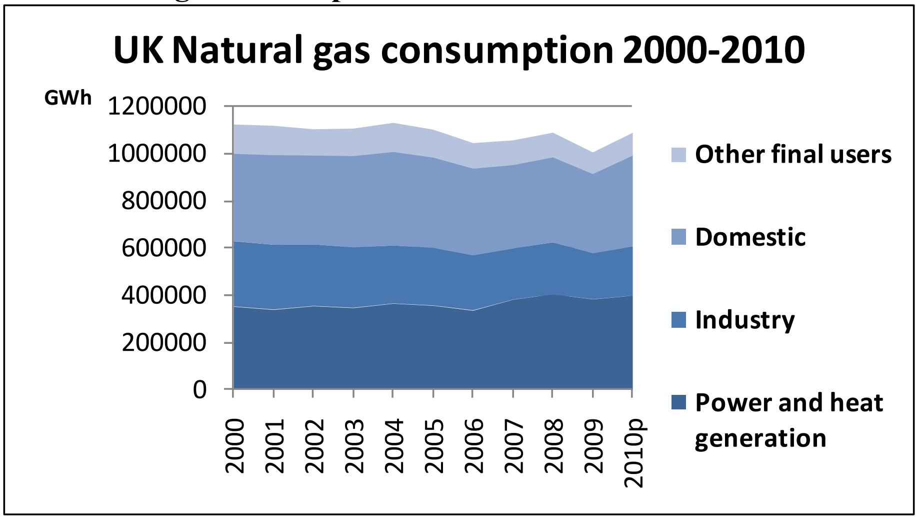
2.2.2 Position of gas

Gas has a prominent position in the UK energy mix. As in the Netherlands, this has been historically determined by the availability of indigenous resources. And as indigenous production has decreased dramatically in recent years, the UK has invested heavily in

[26] Honoré, A., 'European Natural Gas Demand, Supply and Pricing, cycles, seasons and the impact of LNG price arbitrage', Oxford Institute for Energy Studies/OUP, 2010, p. 110,386.
[27] Climate Change Act 2008, chapter 27, part 1, The Stationery Office Limited.
[28] http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/carbon_budgets/carbon_budgets.aspx
[29] HM Government, The UK Low Carbon Transition Plan: National Strategy for Climate and Energy, July 2009
[30] HM Government, 2050 Pathways Analysis, July 2010
[31] Poyry, 'Gas at the centre of low carbon future, September 2010, Pöyry Energy (Oxford) Ltd, p.16

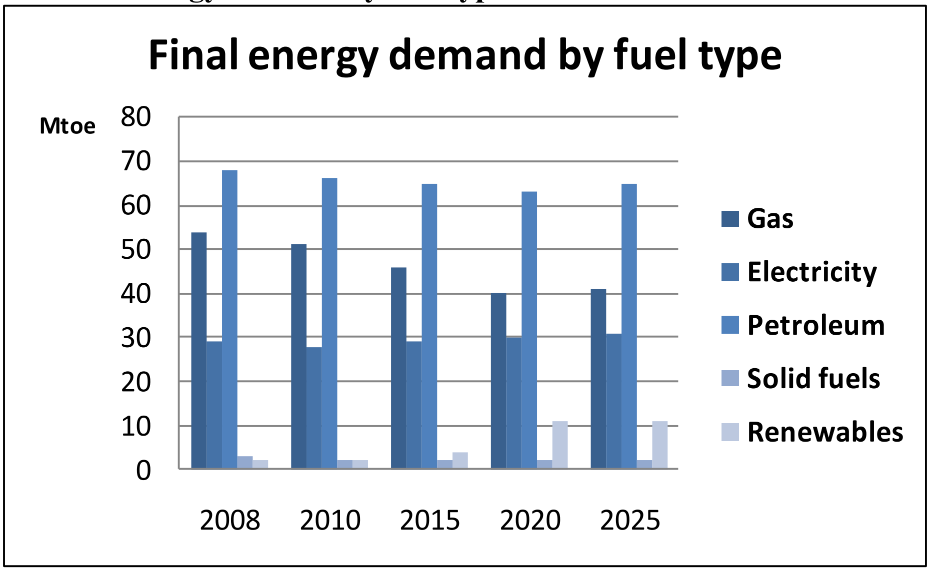
interconnection pipelines and LNG terminals to compensate this decrease with natural gas imports. In 2009, UK gas demand was 93 bcm, nearly 40% of total energy demand[32]. Since 2000, there has been a general trend of slowly declining demand, especially in the industry, which has been amplified by the economic crisis. However, mainly driven by the cold winter, demand picked up in 2010 (see figure 2.2).

Figure 2[33]: UK natural gas consumption 2000-2010



Source: DECC (2010) Updated Energy and Emissions Projections, p. 32

Figure 3: Final UK energy demand by fuel type



Source: DECC (2011) Quarterly tables

Over the next decade, the DECC estimates that gas demand will further decrease. Key drivers are a successful implementation of the renewable energy action plan, energy efficiency measures taking effect, which affects electricity as well as gas demand, and the effects of the

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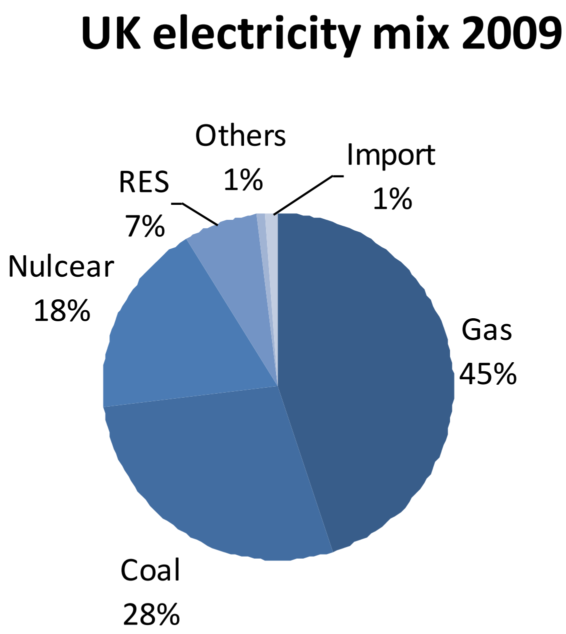
[32] Heather, P., The Evolution and Functioning of the Traded Gas Market in Britain, Oxford Institute for Energy Studies, August 2010

[33] http://www.decc.gov.uk/en/content/cms/statistics/source/gas/gas.aspx. Quarterly tables, last update 31 March 2011.

economic downturn.[34] After 2020, due to expected economic growth and lower nuclear generation as a result of the phase out of old nuclear power plants, gas demand is expected to pick up again.

In power generation, gas is the main fuel. In 2009, natural gas accounted for 45% of electricity production.[35] According to the DECC forecasts, electricity demand is projected to grow by only around 2% in total between 2009 and 2020, with growth restrained by energy efficiency policies.[36]

Figure 4: UK electricity mix 2009



Source: DECC (2010) Energy Statistics, p.120

The electricity sector accounts for 31% of total CO_2 emissions, and is a main target for government emission reductions.[37] Achieving a 30% renewable share in electricity production is an important element in meeting the 2020 emission reduction target of 34%. Furthermore, the closure of coal and oil-fired power plants as part of the Large Combustion Plant Directive (LCPD) and Industrial Emission Directive (IED) (as successor of LCPD) will have a positive impact on CO_2 emissions.[38] Approximately 12 GW is estimated to come offline before 2020. It will probably also have positive implications for natural gas demand as a large part of this decommissioned capacity is to be replaced by gas-fired units. Another main development in power generation is the planned construction of new nuclear capacity. The political basis for these plans is the Draft Nuclear Policy Statement, which is expected to be formally approved in

[34] Department of Energy & Climate Change (DECC), updated Energy and Emissions Projections, June 2010, p.34.
[35] DECC, Digest of United Kingdom Energy Statistics 2010, Chapter 5 Electricity, p.120.
[36] DECC, updated Energy and Emissions Projections, June 2010, p.26
[37] Committee on Climate Change (CCC), Meeting Carbon Budgets, ensuring a low-carbon recovery, 2nd Progress Report, June 2010
[38] DECC, Draft Overarching National Policy Statement for Energy, November 2009, p.16

Spring 2011.[39] Today, 8 sites are still on the nomination list and the first plant is planned to be operational in 2018.[40]

In total, 19GW new nuclear capacity is planned and proposed to start up between 2020-2030.[41] Nuclear power could potentially become an important factor beyond 2020 in decarbonising the power sector and therefore in future natural gas demand. The long term implications for natural gas will be further discussed in chapter 4.

The Committee on Climate Change (CCC) has developed an indicative scenario for the capacity and generation mix in 2020 in the context of decarbonisation of the power sector.[42] They show an increase in gas-fired capacity, but a significant decrease in the share of gas in electricity production. The latter is driven by a dramatic increase in renewable production and a reduction in demand. The CCC states that failure to begin investing in low-carbon plant risks making the sharp cuts required in the 2020s much more difficult or expensive. They also warn of "locking-in" gas beyond 2020 and the need for potentially expensive CCS retrofit.[43]

The DECC projections partly contradict the CCC scenario. The share of new build gas-fired capacity is also high compared to other conventional technologies, but the share of gas in generation remains significant. Despite a decline towards 2020, gas-fired generation in estimated to increase again after 2022.[44] Furthermore, a relatively small amount of new nuclear power capacity is built.

If we look at current developments and existing plans, the outlook for natural gas at least for the coming decade is relatively bright. By 2016, 10.3GW of new gas-fired capacity is expected to come online, which makes natural gas the overwhelmingly dominant technology in power generation in the coming 5 years.[45] This is in line with the CCC capacity scenario. Furthermore, (gas-fired) CHPs are recognized by the government as highly efficient systems for electricity and heat production and part of energy policy. In 2011, installed capacity is approximately 6.3GW and the government projection for 2020 is 12.7 GW.[46]

With respect to the development of low-carbon capacity, it will be challenging to meet the envisaged 28GW wind capacity in 2020. In 2009, 0.7 GW was built and total installed capacity was 4GW.[47] Furthermore, over the coming decade, the government aims to facilitate new nuclear and CCS capacity, although there are also still some major financial, environmental and regulatory hurdles to overcome, to fulfil this ambition.

Another main demand segment for natural gas is heating. Heat production accounts for approximately 50% of final energy consumption and most heat loads are met through direct

[39] https://www.energynpsconsultation.decc.gov.uk/nuclear

[40] The accidents at the Fukushima nuclear facility in Japan could slow down developments or even lead to cancellation of nuclear projects due to, among other things, negative public opinion and political opposition. In Germany, the lifetime extension of nuclear plants is currently being scrutinized since the accidents.

[41] www.world-nuclear.org

[42] CCC, 'Meeting Carbon Budgets – ensuring a low-carbon recovery, June 2010. Also see appendix figure 2.6, 2.7

[43] For an explanation of the "lock in" effect, see Van Foreest, p.25.

[44] DECC, 'Energy and Emissions Projections' June 2010, p. 28.

[45] Reuters, Factbox-British Power Generation Sources, July 2009. Original source: National Grid Seven Year Statement 2009.

[46] DECC, 'Updated Energy and Emissions Projections, June 2010, p.29

[47] CCC, 'Meeting Carbon Budgets – ensuring a low-carbon recovery p. 53

combustion of fossil fuels, mainly natural gas.[48] Natural gas is used for heating in 80% of homes.[49] The government has introduced the Renewable Heat Incentive to reduce the carbon footprint of heating, with an ambition to generate 12% of heat from renewable sources by 2020.[50] In addition, the electrification of heat through the use of heat pumps is a main focus area in relation to energy efficiency. Both developments could have a serious impact on the share of gas in heat supply.

[48] http://www.decc.gov.uk
[49] Pőyry, 'Gas at the Centre of a Low Carbon Future, A Review for Oil & Gas, September 2010, p. 8
[50]http://www.decc.gov.uk

2.3 The Netherlands

2.3.1 Policy framework

As in the UK, natural gas is well-rooted in the Dutch energy system. Although indigenous resources are not depleting as fast as in the UK, the Netherlands will also rely on an increasing share of import to meet longer term natural gas demand. Natural gas is an important topic in Dutch energy policy in terms of market development, security of supply and regulation. Moreover, gas exports provide a large source of income for the government. On the other hand, natural gas is not part of Dutch climate policy. The previous government has set an emission reduction target of 30% and is also bound to the EU renewable target.

With respect to the development of low-carbon technologies, the nuclear option is coming close to reality as the current government has stated that nuclear power can be part of the future generation mix. It could well be the case during this term of government (2010-2014), that approval for construction of at least one plant will be granted. The government has stated that the events leading up to the closure of the Fukushima nuclear plant in Japan will be taken into account in the permitting procedure, but will not lead to a change in policy. Secondly, CCS is part of government policy to reduce emissions. A taskforce has been set up that will focus on creating a legal framework for realization of two demonstration projects by 2015. So far, CCS is mainly linked to coal-fired generation.

In 2008, the previous government published an energy report, which articulated the government's view on challenges and developments in this sector. Although this paper provided a good overview of the issues and possible routes towards realizing the 2020 objectives, it lacked a clear direction for the transitional design of the generation mix compared with that presented by the DECC in the UK. Furthermore, the Dutch government has not defined a CO_2 target for 2050.

2.3.2 Position of gas

The 47% share in the energy mix in 2010, illustrates the strong position of natural gas in energy supply.[51] In 2010, gas demand was 51.9 bcm compared to 46.3 bcm in 2009[52], but this increase is mainly driven by the cold winter and economic recovery. Earlier projections (see figure 2.3) show a lower demand level. In 2020, natural gas demand is estimated at 50 bcm. Residential demand is expected to decrease due to energy efficiency measures[53] But this decline will be offset by an increase in power generation and industry demand.

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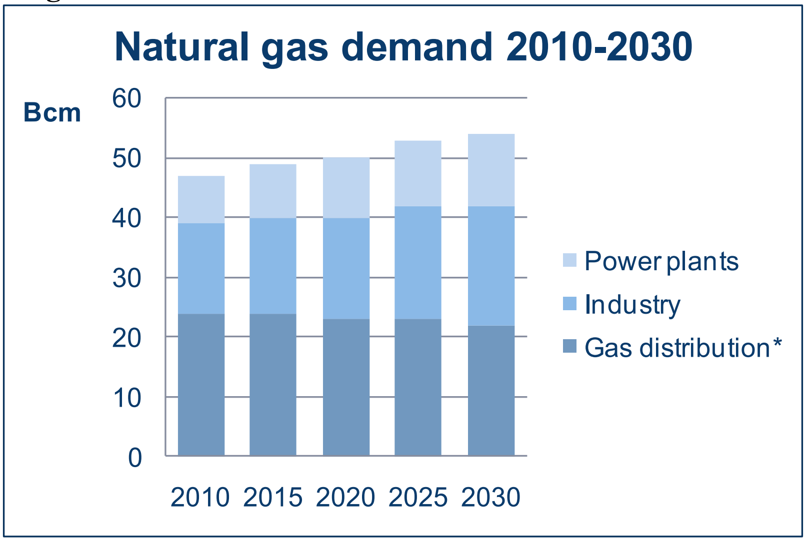
[51] Central Bureau for Statistics (CBS), Energy Balance 2010.
[52] CBS, Natural Gas Balance 2010.
[53] Gas Transport Services, 'Report Security of Gas Supply, Groningen, May 2010, p.8

Figure 5: Natural gas demand 2010-2030



Source: ECN, GTS, CPB
*Gas distribution includes households, commercial buildings and industrial demand

In power generation, including CHPs, gas accounts for approximately 60%. As mentioned above, demand for gas by power plants is estimated to increase as electricity demand increases and the Netherlands becomes a net exporter of electricity. According to a study by ECN (2009) on the fuel mix in power generation in 2020, 32% will be produced by central gas-fired plants and 32% by CHPs. [54] The share of wind will increase, but not sufficiently to meet the target of 37%[55] of power generation that is part of the national renewable energy plan. In 2020, ECN estimates that 6GW will be achieved, compared with the target of more than 10GW.

Up to 2016, 14GW of new gas-fired capacity is planned, of which 4.3 already has a connection agreement with the TSO.[56] Furthermore, CHP capacity has significantly increased since 2000, from 8 to almost 14GW and is expected to stabilize at that level towards 2020.[57]

In addition to the ECN study, other studies on the fuel mix in 2020 have been published. In most scenarios, the share of gas in terms of installed capacity and production remains high (>50%).[58]

With respect to heat supply, small scale technologies for renewable heat such as solar boilers and heat pumps are being supported by the government, but the overall share of renewable heat as replacement for gas-fired heat is expected to be limited in 2020.[59]

Against the background of the existing policies and actual market developments and projection towards 2020, one can conclude that gas will maintain its dominant position in Dutch energy supply and probably even become a bit stronger. National 2050 energy

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[54] ECN, Seebregts, A.J. et al., Fuel Mix Electricity 2020, December 2009. The percentages represent the share of national demand. Part of the production will be exported.
[55] Dutch government, National Action Plan Renewable Energy, Directive 2009/28/EG, June 2010
[56] Tennet, 'Quality and Capacity Plan 2010-2016, November 2009, p.32..
[57] ECN, Seebregts, A.J. et al., Fuel Mix Electricity 2020, December 2009, p.17
[58]Hakvoort, R., Meeuwsen, j., 'Development of the fuel mix of Dutch electricity supply', D-Cision, April 2010
[59] Menkveld, M., (ECN), 'Assessment government program *clean and efficient'*,September 2007, pp.6-7.

scenarios which have been seen in the UK are missing in the Netherlands, but the long term outlook for gas will be discussed in chapter 4.

3. Decarbonisation options for natural gas

In the previous chapter, the position of gas has been discussed in relation to energy and climate policies and scenarios that are developed in the context of the 2020 targets. The CCC scenario for the 2020 generation mix in particular does not show a promising picture for natural gas, but also DECC stated that the long term position of gas largely depends on the success of carbon capture and storage (CCS). The Netherlands has a more optimistic story for gas at least until 2020. Nevertheless, the question is whether, following the DECC point of view, natural gas actually needs viable decarbonisation alternatives first of all to maintain a substantial role in scenarios and roadmaps that can be influential in decision-making by governments, and subsequently maintain this role in the long term energy mix. This chapter discusses the two main decarbonisation options for natural gas; CCS and "renewable gas".

3.1 Carbon Capture and Storage

Decarbonisation of conventional (fossil fuel based) electricity production, i.e. CCS, is one of the main pillars of EU and national climate policies. Although it is not a new technology, capturing large amounts of CO_2 at a power generation facility in a commercially viable way and storing the CO_2 (on- or offshore) is still at an early stage. Many political, economical and technological hurdles have to be overcome before large scale coal or gas generation with CCS is commercially available.

3.1.1 Technology

CCS can be defined as a system of technologies that integrates three stages: CO_2 capture, transport and geological storage. The different stages of CCS technology have already been proven for several decades. CO_2 is removed from gas streams in industry or separated and sold as a product. In the US and Canada, sequestrated CO_2 is transported and injected into oil reservoirs for enhanced oil recovery. Despite the availability of the different technologies, an integrated CCS concept for power generation that can be applied on a large scale commercially, is yet to be developed. In the upstream sector, one example of such an integrated operation is the Sleipner project in Norway. At the Statoil-operated Sleipner field on the Norwegian continental shelf, $CO_2$from produced gas is captured and stored in a subsea aquifer. Emissions of more than 10 million tonnes of $CO_2$to the atmosphere have been avoided since carbon capture started in 1996.[60]

Downstream, in the power sector, capturing large amounts of CO_2 poses a major technological challenge. The three principal capture technologies today are post-combustion, pre-combustion and oxy-fuel. Post-combustion involves scrubbing the CO_2 out of flue gases from the combustion process. Oxy-fuel involves combusting fuel in recycled flue gas enriched with oxygen to produce a CO_2-rich flue gas. Vattenfall's 30 MW Schwarze Pumpe oxy-fuel pilot capture plant in Germany started up in September 2008. Pre-combustion uses a gasification process followed by CO_2 separation to yield a hydrogen fuel gas.[61] Pre-combustion CO_2 capture from an integrated gasification combined cycle (IGCC) power plant has yet to be demonstrated.

[60] http://www.statoil.com/AnnualReport2008/en/Sustainability/Climate/Pages/5-3-2-3_SleipnerCCS.aspx
[61] IEA, 'Technology Roadmap-Carbon Capture and Storage', 2009

Transport of CO_2 is a proven technology. For example, in the US, CO_2 is transported to oil fields for enhanced oil recovery. However, it has not been applied in an integral CCS concept at a power station.

Large scale storage of CO_2 and the variety of reservoirs required for structural CCS deployment have not yet been proven.[62] There are a number of demonstration projects at gas production sites such as the Sleipner project mentioned above and the Weyburn project in Canada, but there is still much uncertainty around technology and costs.[63] Other examples are the In Salah project in Algeria and storage in aquifers at the Gorgon gas field in Australia.[64] In their technology roadmap, the IEA has estimated a storage potential in OECD Europe of 170Mt in 2020 and 15,600Mt in 2050.[65]

3.1.2 Political framework

At an EU level, the CCS Directive (2009/31) is the legal framework and is aimed at facilitating and developing CCS technologies and overcoming legislative hurdles.[66] In support of the EU recovery plan, the European Commission allocated €1.05 billion to six CCS demonstration projects in 2009. Among these projects are the Hatfield (Yorkshire) power plant in the north of England and the Maasvlakte plant in the Netherlands.[67] All six projects are based on coal-fired generation. In addition, in February 2010, the Commission adopted the NER300 Programme whereby 300 million emission allowances (representing a value of approx. €5 billion when auctioned) are to be allocated to finance projects in renewables and CCS.[68]

Of the 43 announced CCS projects in Europe, only six are based on gas. Four of these projects are located in Norway. The current status is that that the Mongstad and Hammerfest project are still waiting for funding. The Norwegian government stated that it would delay the decision to finance the construction of a CCS facility at Mongstad to 2014.[69] With respect to the project at Kårstø, a facility for full-scale CO_2 capture from Naturkraft's gas-fired power plant, the government has halted the procurement process for the assignment of contracts because the project was proving too complex to do on schedule.[70]

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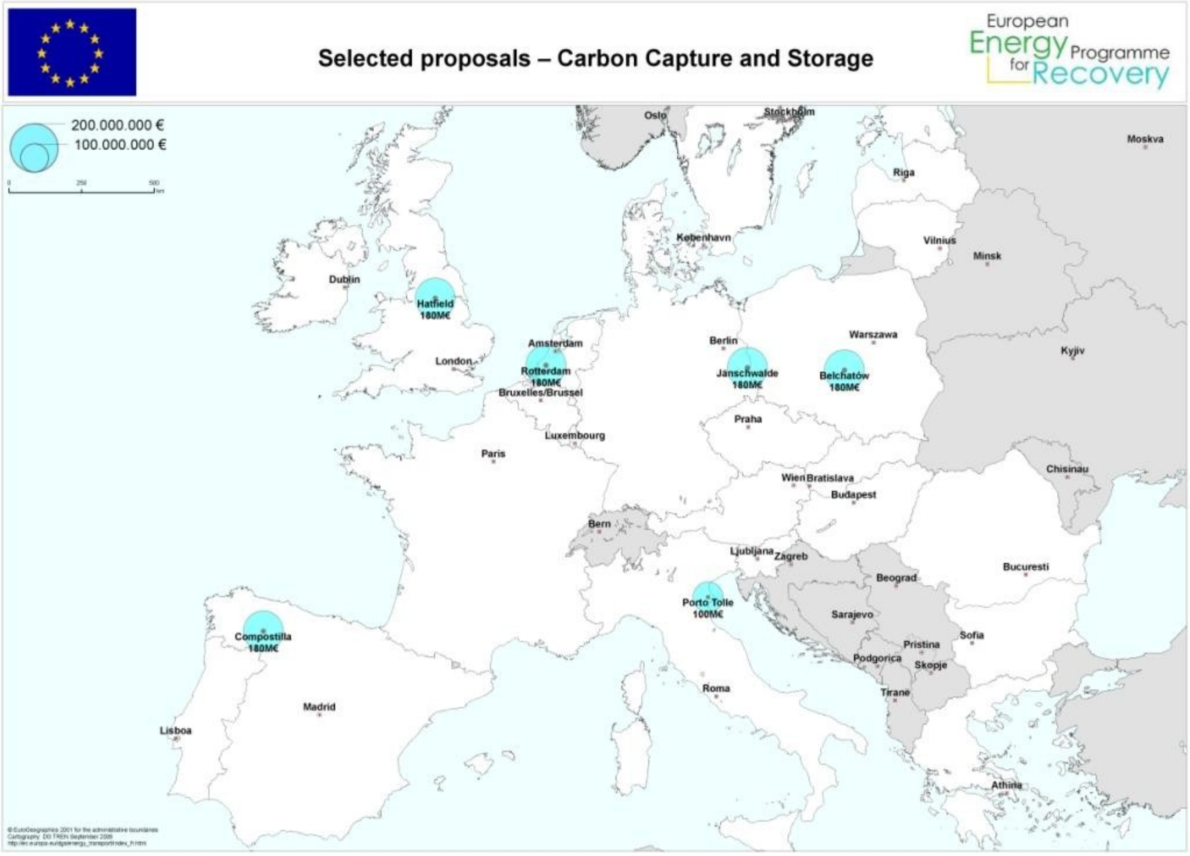
[62] Bakker, S., de Coninck, H., Groenenberg, H., ECN, 'Breaking the deadlock, Carbon Capture and Storage', The Climate Group, 2008.
[63] IEA Technology Essentials, CO_2 Capture and Storage, December 2008
[64] http://www.zeroemissionsplatform.eu/projects/global-projects
[65] IEA Technology Roadmap, Carbon Capture and Storage, 2009, p. 33
[66] Official Journal of the European Union, Directive 2009/31/EC on the geological storage of carbon dioxide, April 2009
[67] http://www.euractiv.com, 9 October 2009, Powerfuel Power Limited, EON-Electrabel (GDF/Suez)
[68] http://www.euractiv.com, 'Commission adopts €4bn plan for renewables, CCS', 4/11/2011
[69] Reuters, 'Norway delays Mongstad Carbon Capture and Storage project, May 2010
[70] Ministry of Petroleum and Energy, 'Carbon capture and storage at Kårstø (update May 2010)'

Figure 6: EU CCS demonstration projects



Source: CCS network EU (2010)

In the UK, an incentive mechanism was included in the Energy Act 2010. It aims to support the construction of four commercial-scale CCS demonstration projects in the UK and the retrofit of additional CCS capacity to these projects should it be required in future.[71] The incentive comprises two elements: a levy on electricity supplies (to be paid by electricity suppliers) and a mechanism for disbursing funds to selected CCS projects. The current focus is on demonstration with coal-fired power stations. The government has set up a funding competition round for building a commercial-scale CCS demonstration plant, but it has encountered setbacks, with utilities withdrawing from the competition. The Longannet project, initiated by a consortium led by Iberdrola-owned Scottish Power, is the only remaining contender.[72] DECC is due to launch a second round of the funding competition in 2011. From 2024 onwards, new coal plants are assumed to be retrofitted with CCS. In June 2010, the Committee on Climate Change wrote to the Secretary of State for Energy and Climate Change arguing that serious consideration should be given to include a gas CCS demonstration project in funding for CCS technology development.[73] The IEA has also stated that CCS is more than a strategy for "clean coal" and the technology should also be adopted by gas and biomass plants.[74] In November 2010, DECC stated that gas-fired plants could also receive funding and be part of the second competition round.[75]

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[71] Energy Act 2010, http://www.decc.gov.uk
[72] Financial Times, 'Competition for carbon capture project to go ahead, 20/10/2010
[73] Committee on Climate Change, Letter to Rt Hon Chris Huhne, Secretary of State for Energy and Climate Change, June 2010.
[74] IEA Technology roadmap, Carbon Capture and Storage, 2009, p.4
[75] Platts, UK's DECC confirms gas with CCS plants could receive funding, 8/11/2010

In the Netherlands also, CCS is part of the Dutch energy and climate policy. The government has the ambition to complete two or three demonstration projects. These projects will probably all be coal-fired .[76] The E.ON plant (1,080 MW), which is currently under construction in Rotterdam, has already been granted an EU subsidy of €180 million. Another €150 million was allocated by the government for a capture and (offshore) storage project in Rotterdam. Although it is more difficult to realize new coal-fired capacity, a number of coal plants are being built or planned. Construction will take place on condition that these plants are 'capture- ready', but the actual implications of this term are rather vague. Capture-ready means that a plant can be equipped with CO_2 capture technology while it is under construction or after it is built.[77] If a plant is not capture-ready, this means it is either more expensive to add CO_2 capture technology or impossible due to insufficient space at the site or no suitable reservoir for storage of CO_2. With respect to storage, three depleted gas fields in the North of the Netherlands were selected as potentially advantageous locations. However, the current government has reversed this policy by stating that there will be no CO_2 storage in this area.[78] Considering the cancellation of a pilot storage project in the city of Barendrecht in November 2010 due to local opposition, onshore storage has effectively been ruled out in the Netherlands[79]

3.1.3 Economics

The point in time when large scale CCS will become economically viable is much debated in the energy sector. In terms of abatement costs, estimates range from \$45-130 t/CO_2 for early demonstration projects, to \$25-80t/CO_2 in 2030.[80] In its 2009 study on the cost of carbon capture, Harvard's Kennedy School estimated a cost range of \$120-180t/CO_2 today, dropping to \$35-70t/CO_2 for mature technology in 2030.[81] In terms of competitiveness with other future power generation technologies, an investment in new capacity with CCS will only be economically attractive if the cost of electricity is below the wholesale power market price. Competitiveness is therefore dependent on how commodity prices develop. On the other hand, the capital component is also an important factor, and coal-fired plants with CCS require an especially large capital commitment.[82] As the technology matures and investment costs potentially decrease due to learning effects and economies of scale, commercial viability will probably improve.

ECN (2009) compared the production costs of new capacity in 2020 for the different power generation technologies.[83] If decisions were made on a pure economic basis, especially nuclear, but also new conventional fossil fuel based generation capacity would be built towards 2020. Furthermore, given assumptions on fuel prices and capital costs, natural gas with CCS is more competitive than coal with CCS. This is also supported by the Mott MacDonald study (2010) on UK electricity generation costs.[84]

[76] E.ON, Electrabel are building a coal-fired plant on the Maasvlakte (Rotterdam), Vattenfall and RWE in the Eemshaven.
[77] MVV Consulting, Ecofys, 'efficiency and capture-readiness of new fossil power plants in the EU, July 2008, p. 4
[78] www.nrc.nl, 14 February 2011
[79] Volkskrant, 'No CO_2 storage in Barendrecht', 4/11/2010
[80] Vattenfall (2007), Boston Consulting Group (2008), S&P (2007)
[81] Al-Juaied, M., Whitmore, A., 'Realistic Costs of Carbon Capture', Belfer Center for Science and International Affairs, Harvard Kennedy School, Harvard University, July 2009, p.32
[82] Estimates range between €1.7 and 2.5 billion. European Commission(2008), Second Strategic Energy Review, *Energy Technologies for Power Generation – Moderate Fuel Price Scenario*
[83] ECN, Fuel mix power generation 2020, December 2009, p.20. Also see appendix figure 3.3
[84] Mott MacDonald, UK Electricity Generation Costs Update, June 2010. Also see appendix figure 3.4.

Regulation will also have an impact on this cost picture and on the actual realization of capacity by 2020. Nuclear power is still a controversial topic in the Netherlands and restrictions could be enforced on building, for example, new coal plants after 2015. Furthermore, an increasing CO_2 price under the third phase of ETS and/or additional financial support from the EU or national governments could improve the perception of the relative cost of CCS.

3.1.4 Coal versus gas

Comparing coal and gas does not seem much of an issue in the development of CCS today. Gas-fired plants are still built and the only way to add or replace coal-fired capacity in the UK and the Netherlands, is the promise of CCS (capture readiness). As mentioned earlier, CCS is mainly focused on coal-fired generation in both countries, but also at the EU level. Apparently, gas is clean enough at present and coal is considered an important fuel for the future. However, following for example the long term view of DECC, all fossil fuels will have to be decarbonised to retain any role in power generation. This would imply that, as has been argued by the CCC, both gas and coal plants will have to be equipped with CCS after 2020. In that respect, the current focus on coal does not correspond with the significant new gas-fired capacity that is under construction or planned in the coming years. Assuming that these plants are built to run for at least 25 years, a large scale retrofit will be the only option.

Arguments that have been used by DECC to focus on coal for CCS demonstration are the importance of installing CCS to the large amount of coal-fired capacity that is being built globally, the high carbon intensity and long lifetime of coal-fired plants and the cost advantage of coal with CCS over gas with CCS, due to the availability of resources and expected increase in gas prices.[85] In terms of economics, competitiveness will depend on which methodology is used. Cost of abatement, expressed as increased cost due to CCS divided by avoided CO_2 (as in the IEA's CCS roadmap), is favourable for coal. On the other hand, if levelised cost of electricity (€/MWh) is used, natural gas has a better case in a number of studies, because although the fuel costs are much higher, the capital and carbon costs of non-captured CO_2 are significantly lower.[86] Transport and storage costs are estimated to be lower for natural gas, but these are a relatively small part of total costs. It should be noted that calculations are highly sensitive to commodity price and technology cost estimates. The CCC argues that cost of abatement is not a valid baseline as an unabated coal plant is incompatible with the UK's emissions targets and would not be allowed to operate even in the near term.[87] However, this is not the case (yet) for other European countries such as the Netherlands.

[85] CCC, Progress Report, p.68
[86] ECN, Mott MacDonald, Harvard Kennedy School
[87] CCC, Progress Report, p.68. In 2009, the previous Labour government pledged not to allow new coal-fired plants without CCS.

Figure 7: Comparison of coal CCS and gas CCS

Parameter	Gas CCS	Coal CCS
Levelised cost of electricity	+/-	-
Abatement costs	-	+
Energy penalty	+	-
Flue gas volume	-	+
Transport	+	-
Storage	+	-

\+ More competitive
\- Less competitive
-/+ Equally competitive

Source: Author's analysis

The relative cost advantage of gas CCS improves at lower load factors, as it is less capital-intensive than coal CCS. Similar to conventional gas-fired power generation, gas with CCS can have a more flexible role in the context of an increasing share of intermittent capacity. On the other hand, it is also argued that CCS is more suitable for base-load power generation, which is more often the role of coal-fired plants than gas-fired plants.

3.1.5 Main barriers for CCS

There are a number of barriers for CCS to overcome in order to become a substantial and competitive technology in the decarbonisation of electricty production. On the economic side, high investment costs, commodity price forecasts (fuel and CO_2) and efficiency loss[88], create uncertainty for investors and cause delay in actual investment decisions. Furthermore, legislative frameworks are still under development, which leads to a lack of clarity for investors, and also negatively impacts the length of permitting procedures.Technologically, large scale capture and storage is not proven, which creates financial as well as environmental uncertainty for investors, but also regulators. Finally, a lack of public support due to for example ignorance or concerns about safety, can hamper development, as we have seen in the Netherlands.

3.2 Renewable gas

Renewable gas is the second decarbonisation option that is discussed in this paper. As mentioned in the introduction, renewable gas is defined as gas that is injected into the gas grid and can therefore be considered a renewable alternative to natural gas. It is produced by upgrading biogas or bio synthetic natural gas (SNG) to almost pure methane. Gases such as carbon dioxide and hydrogen sulphide are removed to create the right specification for injection into the grid. Although renewable gas replaces natural gas, adding it to the gas supply mix could support the image of gas in general as a transition or even destination fuel, thereby also securing the future position of natural gas.

The road to a serious role for renewable gas is subject to several uncertainties common to all renewable energy sources. First of all, the production of biogas has to reach a certain scale. Biogas is a secondary energy carrier that can be produced out of many different kinds of organic materials via either a chemical process (fermentation) or a thermal process

[88] Additional energy that is used in the sorbent regeneration process to remove CO_2.

(gasification). It is considered a renewable energy source[89] and can directly be used for electricity and heat production. It can also be upgraded to natural gas quality (bio methane) and injected into the gas grid or used as vehicle fuel (bio CNG). Estimates of the potential of biogas vary significantly. The Institute for Energy and Environment in Leipzig calculated a theoretical potential for Europe of 166 Mtoe (≈200 bcm) in 2020.[90] The European Biomass Organisation (AEBIOM) estimated a probably more realistic production of 39.5 Mtoe (≈48 bcm) in 2020, which corresponds to approximately 10% of EU gas consumption.[91] Considering the current growth rates, it will be very challenging to reach even this level. In 2008, primary production in the EU was 7.5 Mtoe (≈9bcm).[92] The main sources for production are landfill, waste (agricultural, household, animal) and energy crops. Landfill accounted for the main share in Europe; 37.8% in 2008.[93] The two leading European Union biogas producers are Germany, where production is stimulated via a feed-in tariff incentive, and the UK, which has a green certificates system (Renewable Obligation Certificates). The two countries account for over 70.4% of primary biogas energy production in Europe.[94]

The production of bio SNG through gasification of biomass could accelerate the development of renewable gas. SNG is produced by converting the biomass via gasification into a methane-rich product gas and, after cleaning, conversion of the H_2 and CO in the gas to CH_4 by catalytic methanation. [95] The crude SNG product has to be upgraded to pipeline specification by removal of CO_2 and water. This technology is still in development phase and the timeframe to get to large scale demonstration and commercial implementation is still uncertain.[96]

With respect to the UK, in 2009 National Grid issued a paper on renewable gas in which suggested that it has the potential to make a significant contribution to the UK's 2020 renewable targets (5.6 bcm) and even account for 50% (18.4 bcm) of residential gas demand in the longer term.[97] National Grid uses the term renewable gas as a general term for biogas as well as upgraded gas (bio methane) or bio synthetic natural gas (gasification). Renewable gas is considered as a significant opportunity to supply 'green' heat as an alternative to district heating or heat pumps. Supply through the existing (amortised) natural gas network is used as an economic argument in comparison with other technologies. In 2008, renewable gas accounted for only 1% of total gas demand and, without regulatory support, it will be difficult to meet the 2020 potential set out in the National Grid paper. The proposed Renewable Heat Incentive that is due to be introduced in April 2011 could form a framework for further encouragement of renewable gas.[98]

In the Netherlands, production of biogas is still marginal with only 0.3 bcm produced in 2009.[99] Agriculture accounts for the largest share (44%) of production. The government has

[89] In different policy documents and Directives issues by the European Commission, biogas is covered by policies related to renewable energy and bioenergy.
[90] Institute for Energy and Environment, 'Possibilities of an European Biogas strategy, January 2007
[91] European Biomass Organisation, A Biogas Road Map for Europe, September 2009
[92] 9th EurObserv'ER Report, 'The state of Renewable energies in Europe', 2009, p.54
[93] Ibid., p.52
[94] Ibid., p.54
[95]ECN, http://www.biosng.com/sng-vision/production-technology
[96] According to an indicative time schedule of ECN, large scale demonstration could start in 2012 and commercialization by 2015. However, this schedule dates from 2007 and is probably outdated.
[97] National Grid, The potential for Renewable Gas in the UK, January 2009
[98] National Renewable Energy Action Plan for the UK, June 2010, p.63
[99] CBS, Statline, 'Renewable energy, capacity, production and consumption', 29/11/2010

neither set a clear target for the production of biogas, nor elaborated any vision of the future role of renewable gas distributed via the existing gas network. There is a subsidy scheme for the production of biogas and injection into the grid or use for electricity or heat production,[100] but its sustainability and magnitude are subject to debate in the context of the feasibility of achieving substantial production.

There are a number of hurdles to overcome before renewable gas can become a serious decarbonisation option for natural gas. Maximizing the potential of biogas (fermentation) requires a stable regulatory framework with sufficient financial incentives in order to attract investors. In addition, to reach a significant production level of upgraded biogas and bio SNG, commercialization of large scale gasification of biomass is critical. With respect to transport, harmonization of technological standards for gas injection, gas quality and pressure, at a European level would support further development.[101]

Finally, prices and availability of biomass are a key uncertainty. The gas industry has to compete with the food and electricity industry for biomass; significant additional demand increase could drive up prices. Furthermore, the sustainability of biomass production is subject to debate. The impact on ecosystems and deforestation are issues to be considered in this context.

3.3 Other options

In addition to the two main options described above, the use of gas in the transport sector is often included in discussions about the role of gas as a transition fuel. For passenger cars, compressed natural gas (CNG) or bio CNG are proven technologies that are already used on a small scale as cleaner and/or renewable alternatives to gasoline or diesel. According to estimates of the Natural Gas Vehicle Association Europe, by the end of 2010 the UK only had 20 light duty (passenger cars) natural gas vehicles (NGV) and 280 heavy duty (buses, trucks) NGVs and the Netherlands 2,800 and 700 respectively.[102] There is a clear CO_2 benefit in terms of lower emissions, but adjustment of engines and establishing the infrastructure (filling stations) are main barriers for large scale development. Secondly, for trucks and large vessels, liquefied natural gas (LNG) is already used on a small scale.

In this paper, these options are not further discussed as CNG and LNG based technologies in transport are focused on the use of natural gas as cleaner alternatives to conventional fuels and not on decarbonisation of natural gas. The use of bio CNG or bio LNG can be considered as a decarbonisation option for natural gas in transport, but this development is strongly dependent on the development of renewable gas discussed above.

[100] SDE subsidy scheme.
[101] Stolpp, S., Biogas perspective in Europe, Biogas Regions seminar, 30th June 2010
[102] Natural Gas Vehicle Association Europe, ‘European map of the NGV status end 2010’, 15/02/2011

4. The position of natural gas beyond 2020

Although there is still much uncertainty about realization of the 2020 targets and the corresponding fuel mix by 2020, these targets have been formalized at EU and Member State levels. The period after 2020 is even more uncertain because a political and legislative framework has not yet been established. In addition to the fact that it is more difficult to agree on longer term, legally binding objectives, the current issues around the feasibility of meeting even shorter term targets, could undermine the credibility of those which go beyond 2020. In the WEO 2010, the IEA has made energy demand projections up to 2035. With respect to gas, these projections are basically a continuation of the trends up to 2020 that have been discussed in chapter 2. In the new policies scenario the share of gas in energy demand is 28% in 2035, compared to 25% in 2008. The current policies scenario shows an even larger share of 30%, but the in 450 scenario, this falls to 21%. In absolute terms, gas demand decreases by 20% in the 450 scenario between 2008 and 2035.[103] Clearly, the direction and speed at which gas demand will develop will very much depend on the ambition level of long term climate policies and on the success of their implementation.

In relation to 2050, in 2009, the leaders of the European Union and the G8 announced an objective to reduce greenhouse gas emissions by at least 80% below 1990 levels.[104] This objective has been reconfirmed by the European Council in February 2011. Subsequently, in March 2011, the European Commission has presented a roadmap for possible action up to 2050, which could enable the EU to meet this objective.[105]

The UK is relatively advanced in defining longer term legislation. In the Climate Change Act (2008) three carbon budgets periods have been introduced. The third budget runs from 2018 to 2022 and a fourth budget (2023-2027) is planned to be set in June 2011. Furthermore, a reduction of at least 80% in carbon emissions by 2050 is included in the Act.

As an EU Member State, the Netherlands underwrites the 80% reduction ambition, but there is no clear vision document and policy that reaches beyond 2020. The Dutch government has however defined some parameters of the energy mix in 2050. The main elements are: 40% renewable electricity, a lower share for gas, an important role for CHP and potentially more coal and/or nuclear.[106] In 2011, a new energy report will be published, which could contain measures that reach beyond 2020.

Given the large uncertainties, scenarios or roadmaps have been developed in recent years that show different combinations of technologies and energy saving measures to achieve 80% reduction in greenhouse gases. Decarbonisation of the power sector and achieving high levels of energy efficiency in the industry and residential sectors form the core of the roadmaps that are discussed in this paper. Neither development is positive for natural gas as its share in the energy mix will be significantly reduced.

[103] International Energy Agency, World Energy Outlook 2010, Tables for Scenario Projections, 9/11/2010
[104] Financial Times, 'G8 agrees big greenhouse gas emission cuts', www.ft.com, 8 July 2009
[105] European Commission, 'A Roadmap for moving to a competitive low carbon economy in 2050', COM (2011), 112/4 Provisional Text, 8/3/2011
[106] http://www.rijksoverheid.nl/onderwerpen/energie/energiebeleid-nederland/energiemix-nederland

4.1 Roadmaps

As mentioned above, the European Commission has very recently presented a roadmap to meet the greenhouse gas reduction target of 80 to 95%. It contains a gradual transition that would require 40% reduction by 2030 and 60% by 2040. To assess the potential interaction of climate action on a global level and fossil fuel prices, three scenarios have been developed: global baseline, global action and fragmented action. Table 4.1 shows the main impact on natural gas consumption in the different scenarios.

In Energy Technology Perspectives, the IEA has developed two 2050 scenarios: baseline scenario and blue map scenario. In the baseline scenario demand for gas increases by 38% by 2050, which is mainly driven by an increase in electricity demand and a reduction of coal in power generation.[107] In the blue map scenario, the share of natural gas is significantly reduced in 2050. Decarbonisation of the power sector is dominated by nuclear, CCS and offshore wind. Furthermore, demand for natural gas in the buildings sector (residential and service sector) is dramatically reduced as a result of large energy savings and the use of (low-carbon) electricity for heating.[108] Finally, energy use in industry is reduced by 32% and CCS is also applied to reduce industrial emissions.

The European Climate Foundation (ECF) has initiated the development of a roadmap 2050, which was published in April 2010. The starting point of this roadmap is 80% reduction of greenhouse gases by 2050 and more specifically 95-100% decarbonisation of the power sector.[109] Three pathways for power generation are defined that build on different technology mixes with 40%, 60% and 80% renewable energy (RES). The decline of gas demand ranges from 40-80%.[110] In the 40% and 60% RES pathway, there is a modest share of gas-fired generation with CCS. In the baseline scenario, natural gas accounts for 28% of electricity generation by 2050.

DECC has developed pathways analysis to present a framework through which to consider some of the choices and trade-offs towards 2050.[111] The 6 pathways[112] do not show a promising future for natural gas - it is completely phased out in power generation. In DECC's model, CCS is exclusively linked to coal. However, DECC has also stated that natural gas will remain an important fuel for many years to come, but its precise long term role will depend on developments such as the viability of CCS at commercial scale. In a next version of the model, gas with CCS will also be included.[113] Nevertheless, natural gas is clearly under pressure in these future visions of the power sector.

SEO, a Dutch economic research institute, has looked at the costs and benefits of a sustainable energy supply in the Netherlands.[114] It developed a fossil and renewable route in a business as usual and blue map scenario. One of the main conclusions is that the routes do not differ in terms of societal costs and revenues. They state that preference for a specific route is a political decision. In all the four combinations of routes and scenarios, the position of natural

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[107] IEA, 'Energy Technology Perspectives 2010, Scenarios and Strategies to 2050', 2010, p. 308. Also see appendix figure 4.1.
[108] IEA, ibid p. 323
[109] European Climate Foundation, 'Roadmap 2050, A practical guide to a prosperous, low-carbon Europe, April 2010.
[110] European Climate Foundation, p. 83. Also see appendix figure 4.2.
[111] DECC, 2050 Pathways Analysis, July 2010
[112] See appendix figure 4.3 and table 4.2
[113] DECC, 2050 Pathways Analysis, p.8
[114] SEO Economic Research, 'Investing in a clean future, *the costs and benefits of sustainable energy supply in the Netherlands* ', July 2010

gas is significantly reduced. It is remarkable that natural gas is also largely reduced in the fossil route in the business as usual scenario.[115] An increasing share of biomass and nuclear are the main drivers.

Table 1: Roadmaps/scenarios 2050

Publisher	Title	Scenarios	Impact on gas
European Commission	A Roadmap for moving to a competitive low carbon economy in 2050	Scope of study: EU • Baseline scenario: globally no additional climate action is undertaken up to 2050 • Global action: global action that leads to a reduction of global emissions of 50% by 2050 compared to 1990. At least 80% reduction in EU. • Fragmented Action: EU pursues an ambitious reduction strategy (80%), but other countries do not follow the Global action scenario	• Baseline scenario: no significant change in gas consumption (8% reduction compared to 2008)[116] • Global action scenario: halving gas consumption and reducing gas imports by 60% compared to baseline • Fragmented action: 57% reduction of gas consumption and reducing imports by 83% compared to baseline
International Energy Agency	Energy Technology Perspectives 2010	Scope of study: Global • Baseline scenario: energy demand and CO_2 emission double by 2050. OECD Europe: 8% reduction of CO_2 emission • Blue Map scenario: halve energy-related CO_2 emissions. OECD Europe: 74% reduction of CO_2 emission compared to 2007; 66% reduction in buildings sector and 95% in power generation.	Focus on OECD Europe • Baseline scenario: 38% increase of gas, mainly driven by power generation. 0.7% annual increase of gas use in residential sector • Blue map scenario: Gas demand is dramatically reduced. Only 4.5% of power generation (incl. CCS). Gas consumption in residential and service sector reduced by 77% due to large energy saving.
European Climate Foundation	Roadmap 2050. Practical guide to a prosperous, low-carbon Europe	Scope of study: Europe and focus on power generation • 80% reduction of greenhouse gases by 2050 • 95-100% reduction in power sector • Three pathways for power generation: 40% RES, 60% RES, 80% RES	• Gas demand in power generation decreases by 40-80%. The range refers to the pathways. • In baseline scenario gas demand in power generation increases by 20% • Gas demand shifts to electricity as part of energy efficiency
Department of Energy and Climate Change	2050 Pathways Analysis	Scope of study: UK • 80% reduction of greenhouse gases by 2050	• Gas demand reduced by 80% • No gas-fired generation in

[115] SEO, p.99. Also see appendix figure 4.4.
[116] Gas consumption by 2050 according to the baseline scenario is 405Mtoe. This is a reduction of 8% compared to the 440 Mtoe in 2008 that has been reported by the IEA in the WEO 2010.

		• 6 illustrative pathways that meet emission and energy supply objectives	the electricity mix • Marginal share in the heat sector due to electrification • Gas dominant fuel in reference pathway
SEO economic research	Investing in a clean future Costs and revenues of a sustainable energy supply in the Netherlands	<u>Scope of study:</u> The Netherlands • 80% reduction of CO_2 by 2050 • Two routes. 1) <u>Fossil route:</u> focus on CCS and nuclear; 2) <u>Renewable route:</u> focus on energy saving and renewable energy sources • Two routes have been modelled in *business as usual* and *blue map* scenario. The latter assumes international climate policy	<u>The fossil route:</u> • Blue map scenario: 50% reduction of gas share in energy mix • BAU scenario:70% reduction of gas share in energy mix <u>The renewable route:</u> • BAU scenario:70% reduction of gas share in energy mix • Blue map scenario:80% reduction of gas share in energy mix

As mentioned earlier, the configuration of the long term energy mix is surrounded by uncertainties and therefore also creates a large bandwidth with respect to the share of natural gas. First of all, low-carbon electricity production with large scale intermittent renewable energy, in combination with nuclear and CCS, raises questions about balancing the grid. In countries without large hydro power facilities, gas-fired generation is the main source for back-up capacity. This aspect is not very much elaborated in the scenarios and could have a positive effect on the share of gas in power generation. Furthermore, the scenarios assume large energy savings in especially the built environment, with electrification of heating through heat pumps as one of the prominent instruments. Success in realizing energy efficiency targets partly depends on consumer behaviour, which does not change overnight and creates a large sensitivity in the scenarios. Especially in the UK and the Netherlands, natural gas is the main source for heating in residential and commercial buildings and demand will be strongly affected by significant energy savings and a shift to electricity. On the other hand, the success of electrification is also determined by consumer behaviour and the decline of natural gas in this sector could be less dramatic.

Another uncertainty concerns the industrial sector, which is also a main demand segment for natural gas. The potential for transition in the industrial sector from natural gas to (low-carbon) electricity and renewable energy for flexible steam, heat and electricity production is not obvious. As has been discussed in chapter 3, the share of CHPs is estimated to increase in the UK and the Netherlands in the coming decade. Aside from technological issues, potential costs of using renewable sources and/or applying CCS may affect the competitiveness of industry. This also touches on a more general point of the relationship between policy and market. Government can develop extensive scenarios, but investments have to be made by the energy companies, which may also have to rely on subsidies to get a positive return on investment. Economic behaviour of for example utilities and large industries also has to be taken into account. Huge investments have to be made to achieve 80% reduction of greenhouse gases by 2050. In the ECF study it is estimated that about €30 billion is required in 2010 and up to €65 billion annually by 2025 to implement the decarbonisation pathways in the power sector.[117] The longer these capital commitments are delayed, the higher will be annual investments and the less feasible the scenarios. Commodity price and technology cost forecasts create an additional uncertainty in investment decisions.

It is not a completely negative story for gas. The reference or baseline scenarios in the different reports show a significant increase of its position in the fuel mix. Although these scenarios will also probably not reflect reality by 2050, one could say that if technologies and energy efficiency measures fail or are only partly realized, gas can serve as a relatively clean fall-back technology. Nevertheless, it can be concluded that all other scenarios show a negative outlook for gas.

4.2 Two storylines

The discussion of the scenarios has provided insight into the possible role of gas in future energy balances. Across the scenarios, this role does not look very bright in the context of decarbonisation of the power sector, large scale energy savings and a shift from gas to electricity for heating. In the IEA blue map scenario and the DECC pathway analysis, natural gas has become a *sunset* fuel by 2050. Decarbonisation options for gas (described in Chapter 3) only play a minor role in both scenario studies. The share of gas-fired generation with CCS is limited or eliminated (DECC) and the option of renewable gas is included in relation to transport (IEA) or space heating (DECC), but not on a large scale through injection into the gas grid. Consequently, gas does not maintain any significant share in the energy mix. On the other hand, natural gas becomes more dominant in the reference scenarios. Reality will probably be more nuanced, but if elements of the reference case, such as continuation of large gas use in the industry, become part of energy and climate policy, gas could qualify more as a *destination* fuel.

4.2.1 Sunset fuel

As mentioned above, aside from the reference cases, in all four scenarios natural gas is largely phased out by 2050, and is not replaced by renewable gas. This is driven by a shift away from fossil fuels in power generation and from natural gas to renewable energy and electricity for heating in the building segment. In gas-centric countries such as the UK and the Netherlands, this sunset storyline is only feasible if large scale alternatives are available in both power generation for space heating, as well as for industry. This storyline builds on the following characteristics and assumptions:

Topic	Description
Renewable power	Large scale renewable energy in power generation, offshore wind
CCS	CCS is focused on coal in power generation as it is more competitive than gas and resources are considered to be better located in terms of security of supply
Nuclear	Nuclear power has an important share in decarbonising power generation
Flexibility	Demand for flexibility is partly covered through interconnection and partly by gas-fired units with low load factors
Industry	Gas is partly replaced by biomass and (low-carbon) electricity for

[117] European Climate Foundation, 'Roadmap 2050, A practical guide to a prosperous, low-carbon Europe, April 2010, p.9

	production of steam, heat and electricity
Industry	CCS is also applicable to smaller gas and coal fired CHPs
Industry	Gas is still used as feedstock, but demand is reduced due to shift of industry to low-cost countries
Space heating	Gas is largely replaced as a source for space heating (residential and commercial buildings) by electricity (heat pumps) and district heating in combination with biomass/biogas
Energy efficiency	Energy efficiency measures are very successful, which leads to a significant reduction of energy use in households and commercial buildings
Renewable gas	Biogas is mainly used directly for heat and electricity production and only upgraded to bio methane on a small scale

4.2.2 Destination fuel

If natural gas succeeds in maintaining a significant role across the different end-user segments by 2050, it could be considered as a destination fuel. In the context of this paper, destination refers to an energy mix that has 80% less greenhouse gas emissions compared to 1990. Destination means that natural gas will still be an important fuel by 2050, which could be partly replaced or complemented by renewable gas in the coming decades. Beyond 2050 is outside our scope, but as resources are not infinite, it will probably be harder to qualify natural gas as a destination fuel in an energy future for example to 2100. This storyline builds on the following characteristics and assumptions:

Topic	Description
Renewable power	The share of renewable energy in power generation increases, but the ambitious targets especially for wind are only partly met.
CCS	CCS is also applied to gas-fired stations as this combination is competitive with coal and all capacity that is built after 2010 is retrofitted by 2025.
Nuclear	Nuclear will play a more prominent role, especially in the Netherlands after 2020 where its current share is marginal. However, new capacity mainly replaces coal.
Flexibility	Gas-fired generation is the main source for balancing the electricity grid.
Industry	Gas-fired CHPs will continue to dominate energy production (in line with current developments in both the Netherlands and UK).
Industry	CCS is also applicable to smaller gas and coal fired CHPs.
Industry	Natural gas remains an important feedstock.
Space heating	Natural gas and renewable gas are still a main source for space heating due to presence of extensive gas grid and unsuccessful implementation of heat pumps, mainly due to unfavourable economics.
Energy efficiency	Energy use is reduced, but not as dramatically as in the sunset storyline. Hence gas demand is less affected.
Renewable gas	Due to the commercial availability of large gasification plants, bio-SNG can be upgraded to renewable gas on a large scale (15-20% of annual gas demand)

5. Decarbonisation strategy

In chapter 4, the long term outlook for natural gas was discussed with the help of scenarios of the energy mix in 2050, based on broad assumptions on the commercial availability of technologies, investments in generation capacity and infrastructure and the effectiveness of climate policy. As mentioned earlier, they do not tell a very promising story for gas. On the other hand, this story is largely in contradiction with the actual developments and projections to 2020 that have been described in chapter 2. In both the UK and the Netherlands, but also at an EU level, the share of gas in the energy mix is consolidated or even enhanced in, for example, power generation. This development is extrapolated in the reference scenarios of the IEA, ECF and DECC reports. Consequently, chapters 2 and 4 leave us with an ambiguous picture of the future position of natural gas. The question is whether this ambiguity creates a necessity for natural gas to have a decarbonisation strategy and secondly, what the contours of such a strategy could be.

5.1 Necessity of a decarbonisation strategy

Before addressing the necessity, it should be clear what is actually meant by "strategy" in the context of this paper. In chapter 2, two main decarbonisation options for natural gas have been discussed: Carbon Capture and Storage in combination with gas-fired generation and renewable gas that is distributed through the existing gas grid. The term strategy refers to an integral story about the long term role of natural gas in the energy system that includes a well-funded roadmap for implementation of technologies that reduce the carbon footprint of its current functions. Furthermore, the strategy is linked to natural gas, but it should be propagated by the gas industry, which has an interest in a strong role for the fuel in the long term.

The ambiguous outlook for natural gas has been created by the different targets and scenarios (in chapter 2 and 4). Projections of energy balances in 2020 can be made with greater confidence as some technologies such as CCS and nuclear will not be available on any significant scale within this timeframe. In addition, natural gas has characteristics that enable it already to contribute to CO_2 emission reductions sufficient to meet the 2020 objectives. For example, the *dash for gas* in the UK in the 1990s was the main cause of the 22% reduction that has already been realized. Furthermore, the current position of natural gas is now very strong in the Netherlands and the UK and this position will not radically change over a decade.

Using 2050 as a milestone offers a much longer timeframe in which new technologies can materialize and climate policies can take effect, on national as well as international levels. Reductions of 80% require much more dramatic changes in energy use and supply. This also makes scenarios vulnerable considering the large uncertainties around technology development and implementation of policies.

Nevertheless, the 80% reduction of greenhouse gas emissions has been communicated by governments of leading economies and the European Commission. Although it could partly be interpreted as political rhetoric, the ambition cannot be ignored and it is not unreasonable to assume that climate policies will be largely built around it, which will have consequences for the position of natural gas. The focus will be mainly on low-carbon technologies in power generation, improving energy efficiency and reducing the carbon footprint of heating. In principle, this will negatively affect natural gas because it is a fossil fuel. A passive approach relying on the sustainability of current credentials of natural gas as an efficient and relatively clean energy source runs the risk of the sunset scenario becoming a reality. If for example electrification of heating becomes the standard for new or refurbished buildings, and commercially viable CCS is predominantly applied to coal-fired generation currently anticipated, natural gas could lose ground in a relatively short timeframe. This happened to coal in the UK during the *dash for gas* in the 1990s.The case for natural gas to be part of a long term solution will be strengthened if it can present decarbonisation credentials, instead of being comfortable with a "transition fuel" label. While still mainly at the level of perception, the next few years will see the direction of energy and climate policies crystallize further in terms of support for technologies and long term energy mixes. If a declining share of natural gas becomes a core element of the policy development process, it will be challenging to subsequently reverse this.

A paper by the Gas Advocacy Forum that was published in February 2011 is a recent example of a response by the gas industry to the marginalisation of gas in published energy roadmaps. This paper could be considered as an answer to the ECF study mentioned above. The main argument is that 50% CO_2 abatement compared to 2010 can be realized in 2030 with €450-500 lower investment costs in the power sector through a mix of RES, gas and nuclear.[118] Furthermore, towards 2050, the forum claims that there are different options that are as or more attractive than the ECF 60% RES pathway. The decision for these options could be delayed until 2025.

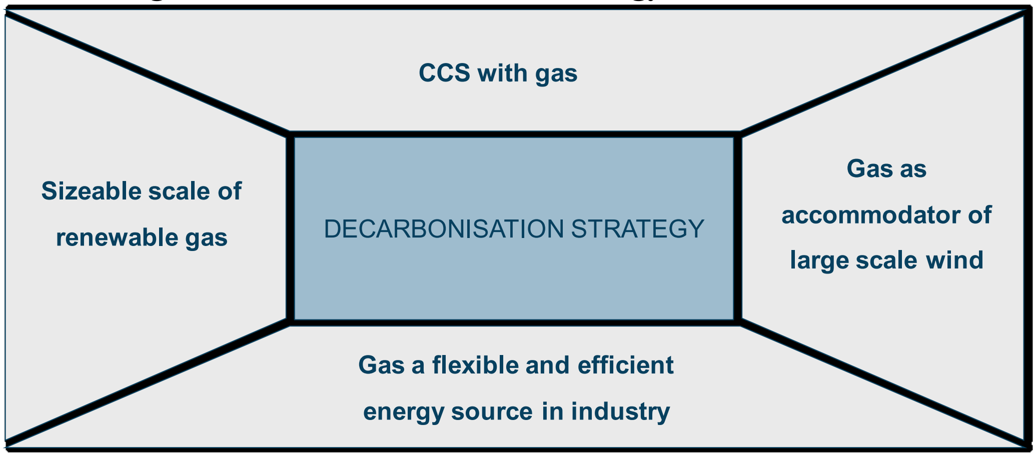
It could be argued that current developments and estimates for the coming decade will result in a *lock-in* of gas beyond 2020. Planned gas-fired capacity in the coming years, in combination with an increasing share of CHPs in industry and the presence of an extensive gas network for space heating, will provide a significant, but probably declining, role for natural gas until at least 2030. However, it does not guarantee any continuation of this position towards 2050.

5.2 Contours of a decarbonisation strategy

If there is to be a general consensus that a decarbonisation strategy is required to anchor natural gas in the energy mix as a destination fuel, instead of running the risk of a sunset scenario, four building blocks will need to be defined and combined into an integrated long term narrative to 2050.

[118] European Gas Advocacy Forum, 'Making the Green Journey Work', February 2011

Figure 8: Building blocks of a decarbonisation strategy



- Gas with CCS. As earlier discussed, the current focus of CCS is mainly on coal-fired generation. Decarbonisation of the power sector is a key step in moving towards 50% and eventually 80% greenhouse gas reductions. Against this background, building new gas-fired plants, and/or retrofitting existing plants with CCS seems inevitable in energy markets such as the UK and the Netherlands where gas is so dominant in power generation. Therefore, gas-fired generation should also be included in the CCS demonstration program. The UK Climate Change Committee already made this argument in June 2010.

- Sizeable development of renewable gas. Upgrading biogas or bio SNG and injection in the gas grid on a relatively large scale (15-20% of annual gas demand) will contribute to reducing the carbon footprint of natural gas. 'Greening the gas grid' would support maintaining utilization of the grid especially for space heating. Development of gasification technology is critical to reach this scale. In the long term, volumes could be further scaled up, but this will (among other issues) depend on availability of biomass. This will require capital commitment and commercial effort to secure sufficient supply of biomass.

- Gas as back-up for large scale wind. Wind is the main renewable source in the context of decarbonisation of the power sector, but also in relation to electrification of space heating. In countries without large scale hydro capacity, gas-fired generation is the most flexible source for providing back-up capacity on very short time scales to ensure electricity grid stability. This aspect has neither been quantified in the 2050 scenarios in terms of required capacity and scale of supply, nor are possible alternatives very well elaborated. The link between intermittent renewable energy, predominantly wind, and gas could be advanced more strongly, supported by concrete examples (e.g. Spain).

- Emphasize the role of gas in industry. Although the use of natural gas to support industrial processes such as feedstock and fuel for steam production does not reduce the carbon footprint of natural gas, it does improve energy efficiency and has lower emissions than oil and coal. Furthermore, low carbon heat and electricity technologies such as biomass boilers and CHPs are not self-evident alternatives for gas that can meet the requirements of energy intensive industries such as iron and steel producers and chemical plants. These requirements can be flexible process-driven heat and steam demand, and gas quality for feedstock. Emphasizing the technological and economic merits of gas as an important fuel in industry and the problems facing alternative fuels, could further enhance the case for gas in this sector. In addition, the potential longer term option of CCS at large industrial sites is also worth considering.

The success of such a strategy will obviously also depend on its economic and technological feasibility. If other low-carbon technologies are economically more attractive than equipping gas-fired plants with CCS or scaling up renewable gas production, this will negatively impact the long term outlook for gas. As discussed in chapter 3, a number of studies show gas with CCS to be competitive with coal with CCS and offshore wind. On the other hand, these studies show the levelized cost of electricity to be lower for nuclear and onshore wind. Economic attractiveness of the different options will depend on regulatory incentives, development of capital costs and commodity prices as well as other factors.

6. Conclusion

There is no clear-cut answer as to whether natural gas needs a decarbonisation strategy to preserve its longer term position in European energy balances. Current developments and estimates by energy organisations for the coming decade provide a relatively positive picture for natural gas. At the EU level, the share of natural gas in total energy consumption either increases a bit or slightly decreases if carbon reduction policies are successfully implemented. Both in the UK and the Netherlands, natural gas is the mainstay of the energy system with shares in the energy mix of 40% and 45% respectively (and much more if the transport sector is excluded). In the UK, more gas-fired capacity is under construction, but natural gas production will decline. The Climate Change Committee has presented a scenario where the share of natural gas in power generation is more than halved in 2020. DECC on the other hand has a more optimistic forecast for gas with a smaller decrease by 2020 and an increase again up to 2025. In the Netherlands, gas demand is even expected to slightly increase in the coming decade mainly driven by power generation.

Contrary to scenarios of demand decline, it could be argued that natural gas has a sufficiently strong basis for the longer term. Its relatively clean characteristics in combination with the uncertainties around the large scale development of low-carbon alternatives, could make natural gas the *default* fossil fuel. On the other hand, the examination of four 2050 energy scenarios has shown that the gas industry should be concerned about the way in which its future is being depicted. The studies which have been surveyed in this paper show the share of natural gas being dramatically reduced as a result of decarbonisation of the power sector, large scale energy savings and a shift from gas to (low-carbon) electricity in space heating.

To achieve an 80% reduction of greenhouse gas emissions by 2050, drastic changes in energy balances are required which will affect the position of natural gas. In this paper, two decarbonisation options for natural gas have been reviewed that could partly mitigate the downward effect on its share in the long term energy mix. First CCS in combination with gas-fired generation is the technology that enables a continuing role for natural gas in low-carbon power generation. Today, the main focus is on CCS with coal. Although there are large uncertainties about the economic and environmental feasibility of this technology, the dominance of coal could negatively affect the position of natural gas in the longer term. The fact that gas with CCS is not included in the DECC scenarios is illustrative of this potential outcome.

Second, renewable gas is a low-carbon option to 'green' the gas grid. Through upgrading and injection of biogas or bio SNG, renewable gas could replace some natural gas, and also support a long term future for gas in space heating. A critical success factor is the commercialization of gasification technology, which would facilitate large scale production as the potential of biogas is limited.

Although it is uncertain whether low-carbon technologies will be developed on a sufficiently large scale to achieve the 80% reduction by 2050, it is reasonable to assume that the energy mix will move towards a more sustainable, low-carbon configuration. In this context, a long term strategy for natural gas would be to anticipate such an outlook. Relying on a continuation of current developments for the next 10 years risks a *sunset* scenario for gas. Furthermore, if a significant decline of gas demand becomes anchored in climate policies, it will be challenging to radically change this perception.

Today, gas does not have a decarbonisation strategy. The claim to be a transition fuel is not backed by a clear story about which technologies and in which timeframe the carbon footprint of gas can be reduced sufficiently to be considered an acceptable long term energy source. Waiting for governments to present more concrete policies for the development of CCS with gas, and/or large scale renewable gas, or relying on failure of non-gas low-carbon alternatives, makes a *sunset* scenario more probable.

The term "strategy" refers to a convincing narrative about the long term role of natural gas in the energy system that includes a well-funded roadmap for implementation of technologies that reduces its carbon footprint in current end uses. The building blocks of this strategy are the earlier mentioned decarbonisation technologies, the positive link between gas-fired generation and large scale intermittent renewable energy, and the essential role of natural gas in industry as feedstock and provider of flexible steam through industrial CHP's.

A decarbonisation strategy cannot be limited to statements of principle, it must be substantiated by commitments in terms of footprint reduction targets and timelines. The strategy should be set out by the gas industry, which has a clear interest in a strong, long term role for the fuel. For example, upstream companies need to set emissions reduction targets for exploration and production of gas. Power generators need to make commitments in relation to reductions from gas-fired generation. Suppliers of gas could commit to concrete objectives for a certain share of renewable gas in their supply mix. Adopting concrete commitments on the carbon footprint reduction of gas is essential to any credible claim for gas as a *destination fuel* in long term energy balances.

Gas industry stakeholders regularly express the views that:

- low carbon supply sources – renewables, nuclear power and coal with CCS - will fail to be implemented to the necessary extent within the required time frame;
- gas for coal substitution will be the lowest cost way of achieving the 2020 carbon reduction targets,
- and as a consequence that gas will inevitably become the "default" choice for future power generation.

Only time will tell whether such calculations prove to be realistic or overly complacent. But even if realistic, they seem unlikely to convert policy makers and environmentalists to the view that gas is a long term solution, as opposed to a short term fix, to decarbonise energy balances. Failure to achieve such a conversion will mean that although greater use of gas may be tolerated in the short term, the gas industry has yet to win carbon-related arguments which would ensure its long term future in European energy balances.

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Appendix

Chapter 2 Current position of gas

Figure 9: CCC scenario capacity mix 2020

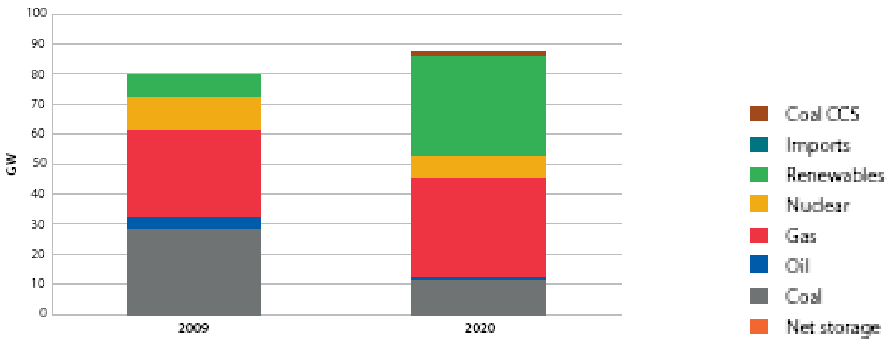
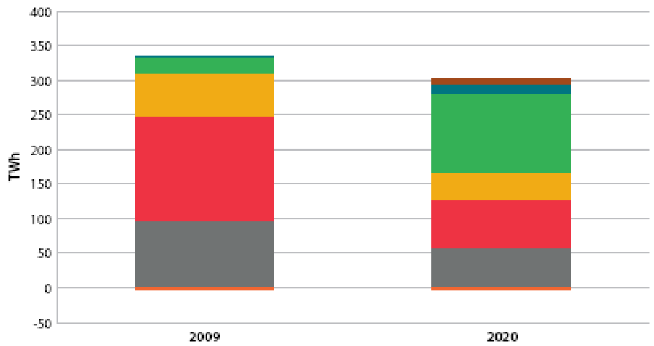
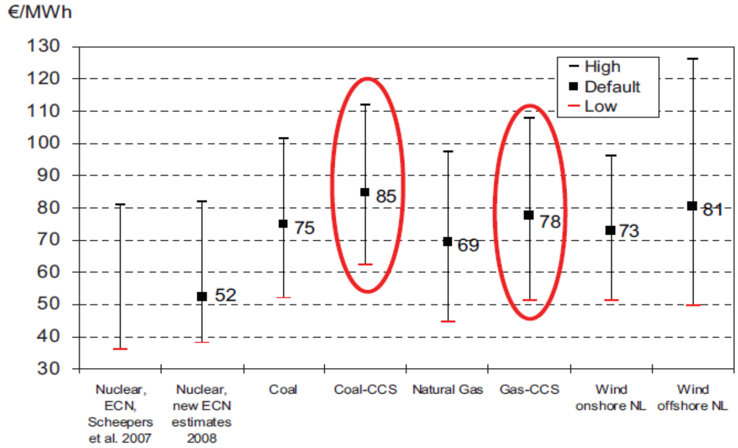


Figure 10: CCC scenario power generation mix 2020



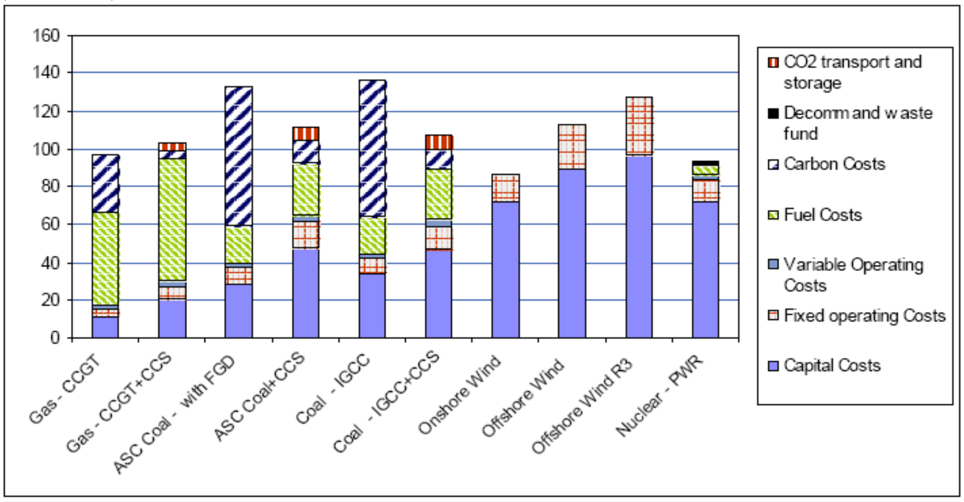
Source: CCC progress report 2010

Figure 11: Integral production costs of new capacity in 2020[119]



Source: ECN 2009

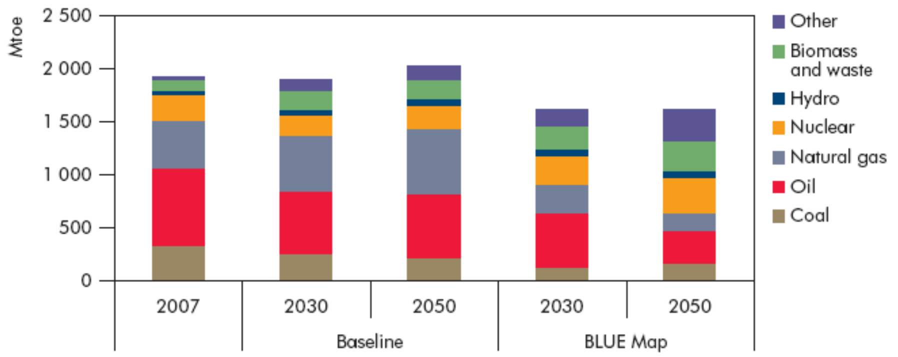
Figure 12: Levelised costs of main technologies on NOAK basis project started in 2017 (£/MWh)[120]



Source: Mott MacDonald 2010

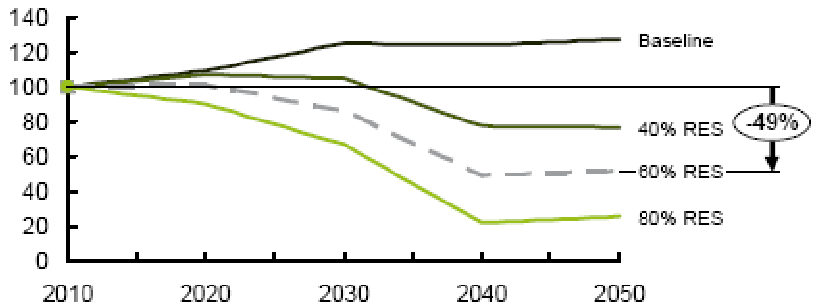
[119] ECN, Fuel mix Electricity 2020, December 2009, p.20. For assumptions on commodity prices and efficiency levels, see also page 20.
[120] N[th] of a kind (NOAK), Advanced Supercritical Coal, Flue Gas Desulphurization (FDG)

Figure 13: Total primary energy supply by fuel for OECD Europe, Baseline and Bluemap scenarios



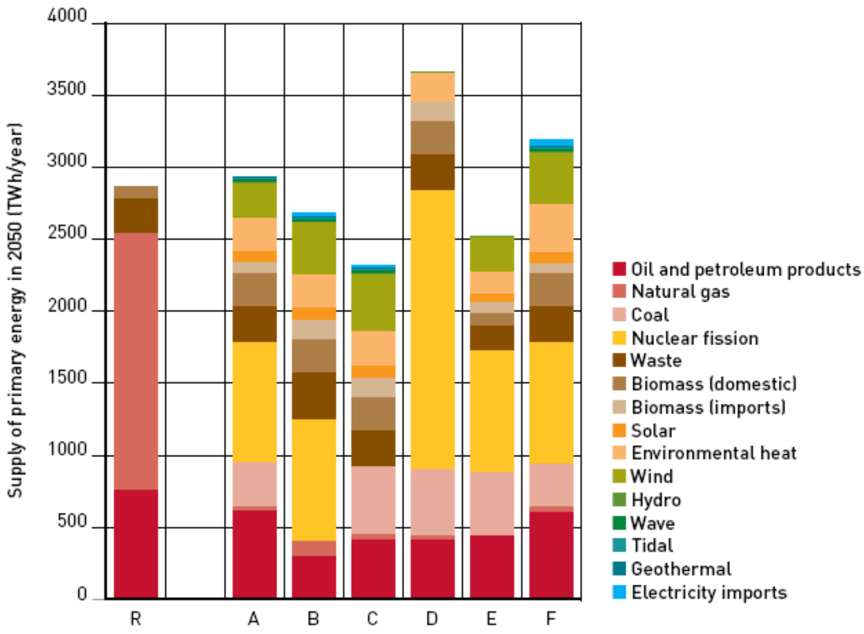
Source: IEA, Technology Perspectives 2010

Figure 14: Gas demand for power generation, indexed to 100 in 2010



Source: ECF 2010

Figure 15: Summary of energy supply in 2050 across illustrative pathways



Source: DECC 2010

Table 2: 2050 DECC pathways

Pathway Alpha	Largely balanced effort across all sectors, based on physical and technical ambition. Three large scale sources of low carbon electricity (renewables, nuclear, and fossil fuel power stations with carbon capture and storage); and a concerted effort to produce and import sustainable bioenergy.
Pathway Beta	Carbon capture and storage not feasible
Pathway Gamma	No new nuclear capacity is built
Pathway Epsilon	Supply of bioenergy is limited
Pathway Zeta	Little behaviour change on the part of consumers and businesses.
Reference case	Little or no attempt to decarbonise, and new technologies do not materialise

Source: DECC 2010

Figure 16: Production - primary energy sources by fossil route in

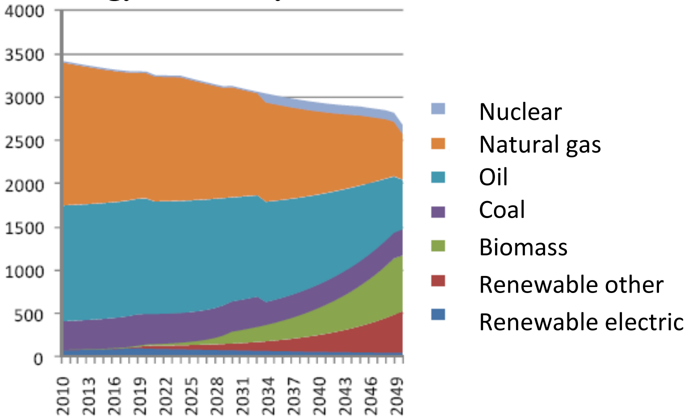
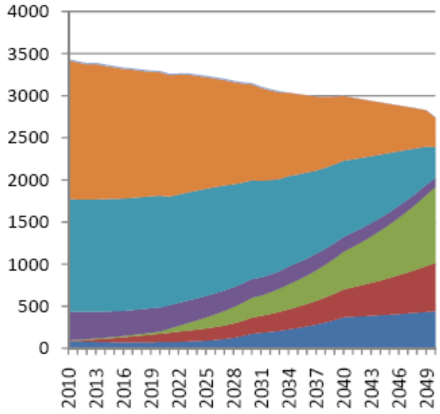


Figure 17: Production - primary energy sources by renewable route in



Source: SEO 2010