3

What Outlook for European Gas Demand? An Overview of Possible Scenarios

Anouk Honoré

3.1 Setting the Context

3.1.1 Natural Gas in Europe: A Story of Success…

Natural gas consumption in Europe[1] had been a story of success since its early developments in the 1960s. Northern European markets, closest to the onshore Dutch discoveries and those offshore the UK, Norway and Denmark were the first to develop at scale, displacing coal and oil products in the space heating and industrial sectors. Since the mid 1990s, the widespread adoption of the highly efficient combined cycle gas turbine in liberalised markets with ambitions on curbing carbon dioxide (CO_2) emissions provided an additional spur for European gas demand in the power sector, again replacing coal and oil products.[2] The market share of natural gas has increased rapidly from less than 10% of the total primary energy supply (TPES) in the early 1970s to about 23% in 2015 (Fig. 3.1).

A. Honoré (✉)
Oxford Institute for Energy Studies, Oxford, UK
e-mail: anouk.honore@oxfordenergy.org

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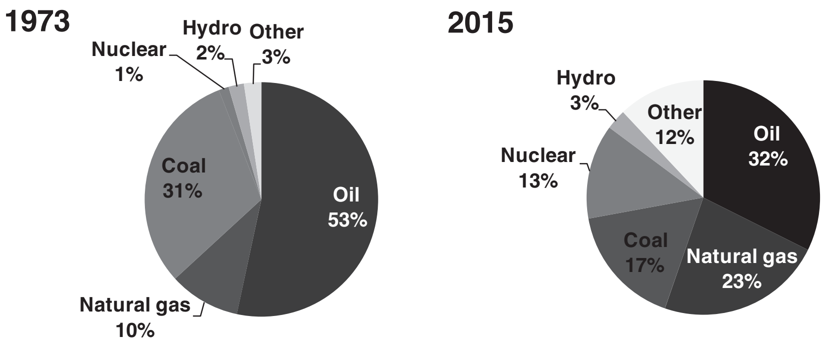

Fig. 3.1 Total primary energy supply in Europe, by fuel in 1973 and 2015 *Source* Based on International Energy Agency data from International Energy Agency, *Natural Gas Information 2016 Edition* (Paris: OECD, 2016), III.17

3.1.2 … at Least Until the Mid 2000s

Rapid gas demand growth slowed in the mid-2000s as a result of a maturing market, low population growth, higher gas prices (in large part due to the oil price linkage in much of its contracted imports), growing competition in the energy mix and the migration of manufacturing industry to other world regions. Weather corrected data shows that gas demand peaked in 2008, although observed gas demand peaked in 2010 as a result of especially cold temperatures that year. The key message is that the fundamentals, which had been historically driving gas demand up, had already changed when the effects of the economic recession started to be felt. Therefore, the 2008/2009 financial crisis and subsequent recession happened in a context of already moderating gas demand growth in Europe.

Contrary to earlier scenarios,[3] gas demand fell in the early 2010s (between 2010 and 2014) to levels not seen since the late 1990s.[4] Most of the sectors (except transport) were hit by the combined effects of slow economic growth, improvements in efficiency measures, relatively high gas prices (especially to coal prices) and the development of renewable energy. Total gas demand picked up year on year in 2015, mainly thanks to colder temperatures in the early months, and reached 472 billion cubic metres (bcm),[5] still 96 bcm below its record level of 2010.[6]

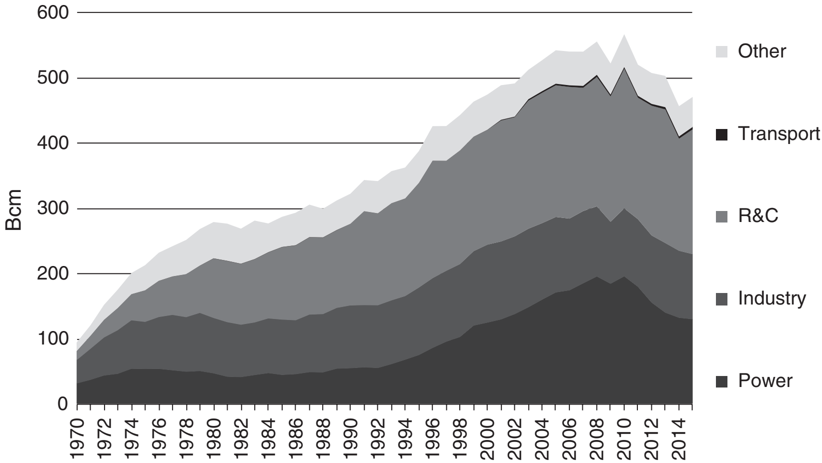

Fig. 3.2 Natural gas demand in Europe, by sector (1970–2015). *Source* Based on International Energy Agency data from International Energy Agency, *Natural Gas Information,* several editions (Paris: OECD); Data for 2015: author's estimates, in Anouk Honoré, "Demand production vs demand destruction" (presentation at the Flame Conference, Amsterdam, 11 May 2016)

The most impressive evolution happened in the power sector, which lost about a third of its gas demand in 2010–2014 (Fig. 3.2). A combination of factors explain this: the economic slowdown restricted power demand growth which, combined with the fast increase of renewable energy,[7] left little room for other fuels in the generation mix. A sharp drop of coal prices since 2011 made coal more competitive than gas over the period,[8] a situation reinforced by the parallel decline of the price of carbon in the European Union Emissions Trading Scheme (EU ETS).[9] As a result, from early 2012, spark spreads were negative, or at least well below dark/clean dark spreads, in most European countries. This unprecedented evolution casted a shadow of uncertainty on prospects for a continued future gas demand growth in Europe.

3.1.3 Uncertainties on Future Gas Demand Growth

In the early 2000s, expectations of growing European gas demand were still largely undisputed, when natural gas was the fuel of choice for new power generation capacity and was seen as the key driver for additional demand in the next two to three decades at least. The development of low carbon policies created slow changes in the energy mix but without too much effects on the gas industry thanks to energy and power demand growth, which left enough room for gas even in a growing competitive environment. Nonetheless, scenarios taking into account a more optimistic development of environmental policies, with fast growing renewables and the maturity of the older gas markets, started to question the linear trajectories of gas demand growth.[10] Scenarios were still showing growth, but expectations were revised down. For example, the IEA expected 868 bcm in 2030 in its World Energy Outlook (WEO) published in 2002, but revised its expectations to 615 bcm in 2030 in its WEO 2010 and to 520 bcm in 2030 in its WEO 2015.[11]

The energy world and of course the gas industry are not isolated from what happens in the rest of the economy, and the impacts of the economic crisis of 2009 came as a shock for many gas players. Gas demand in Europe lost more than 33 bcm in 1 year alone or about 6% of total gas consumption. More importantly, the following years reminded everyone that natural gas does not have a captive market, and its market share can evolve quickly, especially in the power sector (21% of total gas demand in 2015[12]). The COP21 meeting held in Paris in December 2015 resulted in an agreement between 195 governments to cooperate to hold global temperature increase below 2 ℃. To achieve this target, a global peaking of Green House Gas (GHG) emissions and emissions neutrality after 2050 are needed. Policy measures in the European Union and in various Member States also focus on reducing emissions progressively up to 2050. Although all sectors are expected to contribute, the power sector is seen as the biggest potential for cutting emissions. Electricity is expected to come from renewable sources like wind, solar, water and biomass or other low emission sources such as nuclear power plants or even fossil fuel power stations equipped with Carbon Capture and Storage (CCS) technology. All these factors, both at the regional and at the national levels, have created a level of confusion as to the future of gas in Europe that is unprecedented, and even raises the possibility of a peak demand for gas having occurred in 2008/2010.

3.2 Future Gas Demand Growth in the Power Sector?

3.2.1 Eroding Role of Natural Gas in the Power Generation Mix

In the first half of the 2010s, not only has gas demand for power generation declined faster than total gas consumption[13] but gas has also lost market share to other fuels (Fig. 3.3).

In the power sector, electricity produced from gas can be substituted by electricity produced by other readily available fuels. The main option, one which can be done quickly (and on a much larger scale than by using oil products), is to use additional coal, although this would add significantly to carbon emissions (and potentially create other environmental problems). Switching from gas to coal

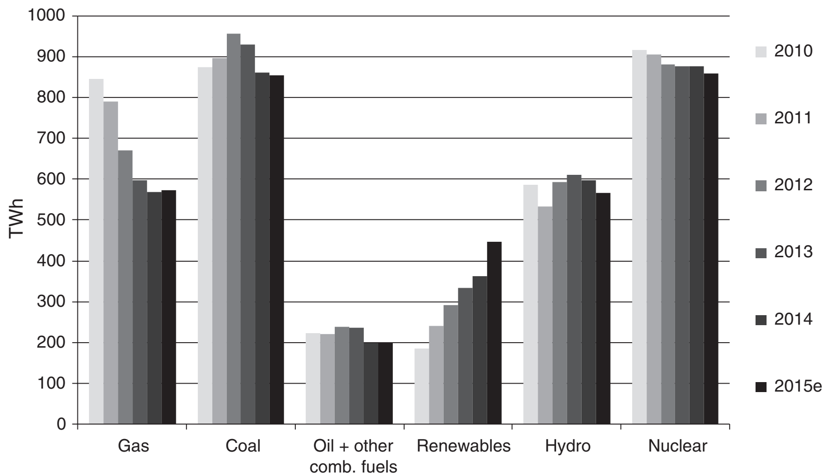

Fig. 3.3 Power generation mix in Europe, by fuel (2010–2015). *Source* Based on International Energy Agency data from International Energy Agency, *Electricity information,* several editions (Paris: OECD); Data for 2015: author's estimates, in Anouk Honoré, "Demand production vs demand destruction"

happened in 2010–2012 due to competitive coal prices relative to gas and low carbon prices in the EU ETS system. Coal continued to be an important competitor to gas, but post-2013, the share of coal in the mix also started to decline due to various coal plants closures as a result of the Large Combustion Plant Directive (LCPD). In 2015, the share of coal in the mix was slightly below its level in 2010, certainly not higher.

Nonetheless, the decline in the share of electricity generated from gas continued. This was due to flat power demand and rapid growth in renewables such as wind and solar, which contributed to just about 13% in 2015 (compared with 5% in 2010).[14] Between 2010 and 2015, the share of natural gas in total generation mirrored the evolution of the share of renewable, but in the opposite direction as the share dropped from 23 to 16%—not far from its level in 2000 (15.7%).

While renewables benefit from priority dispatch in power generation,[15] wind and solar—the two fastest growing renewable energy sources in Europe—are both intermittent and unpredictable. Their availability depends on external factors such as sunshine and wind. They cannot be switched on and off as needed, unlike other power plants. As a result, direct substitution of gas plants by renewables is limited. But their growing share in the mix, and flat growth of power demand post-recession, has had a major impact on power generation from gas.

In 2015, natural gas was used mostly in applications (such as combined heat and power plants) which must run or when gas-fired stations are needed to meet short-term capacity (such as peak shaving, which does not involve large gas volumes).[16] Gas for power demand showed some signs of recovery in 2016 thanks to lower gas prices, higher coal prices in the second half of the year and continued closures of coal plants, which triggered some hope of small improvement this side of the 2020s.

3.2.2 Drivers and Constraints: Conflicting Factors

There are numerous factors that influence gas consumption, and these differ from one country to another depending on the national characteristics such as indigenous resources, supply contracts, transportation capacity (and access to it), power generation mix, policies, taxes and financial support mechanisms. Economic growth and gas price competitiveness also remain key elements in the evolution of gas consumption. However, the future role of gas in Europe will increasingly be a consequence of what kind of energy policies and environmental measures are put in place both at the regional and at the national levels—and also their affordability, which might limit their ultimate scale.

The role of gas in the energy mix is driven by the overall consumption of energy, which is a function of gross domestic product (GDP) and energy efficiency, and by competition with other fuels in the different sectors. The European Union has made the mitigation of climate change one of its key priorities. The Kyoto protocol, the 20-20-20 targets, the 2030 framework (Fig. 3.4) and the 2050 roadmap all propose to transform the region into a low carbon economy via three main measures: increasing renewables, a CO_2 cap and price and better efficiency. Despite the ambitious policies and targets proposed at the regional level, the measures decided by the European Union mainly set a common structure, as energy remains an important economic and strategic challenge for national governments. Energy policies are still very much a matter of national interest albeit inside the regional framework of the decarbonisation of the economy. It is a complicated and questionable task to try to sum up the policies of the very different European countries, but it is fair to say that natural gas has not been getting much attention in energy policy, or better said, the focus is almost always entirely placed on other technologies or objectives that will, on a short-term or long-term basis, have an impact on the use of gas. This creates a high degree of uncertainty in the gas industry. Will gas for power demand ever recover? This will depend on several—sometimes conflicting—factors.

Fig. 3.4 EU framework for climate change and energy, targets for 2020 and 2030. *Source* Author elaboration from http://ec.europa.eu/clima/policies/strategies

- First, the continued policies aimed at improving energy efficiency mean that even with some GDP growth,[17] the effects on energy and power demand are likely to be flattened by these measures.[18]
- Second, renewables are at the centre stage of the European energy policy framework. As part of the EU framework for climate change and energy, renewable energy is expected to continue to rise albeit at a slower pace than seen since the early 2000s due to the downward revision of support schemes across Europe. Upgrades and better interconnections between countries will also contribute to sustaining the role of renewables, in order to meet the EU 2020 and 2030 targets.
- Third, the competitiveness of gas prices against coal prices is not expected to change dramatically over the period (with the expection of the second half of 2016). This is because coal prices are expected to remain low, and the pricing of carbon within the EU ETS is unlikely to climb high enough to make a difference in the dispatch order, despite a series of measures envisaged by the European Commission.[19] The low(er) liquefied natural gas (LNG) prices expected in the second half of the 2010s and early 2020s will create some demand in the power sector, but gas prices will need to drop to very low levels to start making a real difference in the regional mix. It is impossible to give a "magic price" (of gas, coal, or EU ETS) at which coal-to-gas switching would start to happen in the whole region, due to the wide heterogeneity of the market.[20] As an illustration, in a market with spare capacity to be used and highly efficient gas and coal plants, at a gas price of $4/MMBtu and a coal price of $50/t, switching may happen at a carbon price of about 20 €/tCO_2.[21]

It is hard to imagine any of those factors being reversed anytime soon, at least this side of 2020, but one can be cautiously optimistic. Lower gas prices thanks to a global LNG glut[22] are raising new hopes of gas demand recovery, but additional measures would be needed to trigger a shift to gas in the short term, like in the UK for instance. In this country, the carbon price floor (a national measure which comes on top of the EU ETS price and which reached £18 in April 2015[23]) changed the relativity of the spark and clean dark spreads, with more gas being used in the system and even some days in 2016 with no coal at all in the mix (an event that has not happened in over 100 years). The UK example will not be easily replicated as the special characteristics of the market have contributed to this evolution[24] such as the type of gas plants in the market (mostly Combined Cycle Gas Turbines—CCGTs—belonging to utilities which are more reactive to price changes), the closure of several gigawatts (GW) of coal capacity due to the LCPD, the still relatively low level of renewables (including hydro), and maybe even more importantly, the limited interconnections with the rest of the European system. Exactly how this model can be replicated in other markets is uncertain due to differences between markets, but it has the merit to offer a concrete example that something can be done with higher CO_2 prices.

3.2.3 Role Still Has a Role to Play… in Theory

One should bear in mind that a return to the situation as seen in the 2000s is impossible. The power sector lost about 65 bcm between 2010 and 2015 in Europe, and even in a theoretical scenario of a return to the level of competitiveness between coal and gas seen in 2010, this would probably translate into only about 30 bcm of additional gas demand due to the rise in renewable generation in the mix in the meantime,[25] all other factors being equal.

However, "all things will not remain equal" and some existing capacity will close down in the time frame, due to EU Directives, national measures, old age and inefficiency.[26]

- Some plants have been pushed out of the system already, as a result of the LCPD (around 55–60 GW by the end of 2015),[27] and some additional ones will also opt out of the Industrial Emissions Directive (IED) and will close down by the first half of the 2020s.[28] Although it was too soon to tell at the time of writing, as many generators decided to include their plants in the National Transition Plans which gives them time to decide to invest or not to comply with the directive,[29] the IED and additional measures on GHG emissions will probably lead to the closure of between 50 and 100 GW by the mid 2020s.[30]

- Finally, some nuclear capacity will shut down due to economics but also political decisions to either phase out nuclear or to decrease the role of nuclear in the mix.[31] The removal of this (large amount of firm) capacity will create a gap between the need for power generation and the capacity in place.

As a result, the gap will rise between power demand and how much renewables can fulfil (even with flat power demand and rising renewables in the mix). Much will depend on how big the gap is and how it is filled. The number of new coal plants will be limited as investment decisions are complicated by low baseload electricity prices and the difficulty of obtaining approval for construction due to environmental regulations (mostly in Western Europe). There is no coherent strategy on nuclear power in Europe,[32] but the nuclear generating fleet is ageing and limited new capacity is also to be expected.[33] It would be optimistic to see any substantial increase in nuclear power production in Europe post-2020. The main issue for nuclear power is, rather, prolonging the operating life of existing stations beyond original design and acceptance by the population. The gas-fired generation will benefit from expected closure of firm capacity (coal and nuclear), especially in the 2020s.

Although the exact amount of retiring plants is yet unknown, this will leave some space for gas in the mix as renewables will not be able to compensate the entire loss, and new coal, nuclear and even large hydro power plants will be limited. Even in a world of tighter and lower carbon emissions, there is a possible role for gas in the generation mix in Europe, but this will require that enough gas plants are in place and ready to be used (which is yet uncertain) and more importantly that the gas industry manages its high-carbon status in the 2020s and beyond by developing power stations equipped with CCS technology (the timing of which is also yet uncertain).

The main unknown is whether gas will be able to play its role when the time comes. About 50 GW of gas-fired plants were closed down or mothballed in the first half of the 2010s[34], and very few new non-renewable plants have taken final investment decision (FID) since the 2008/2009 crisis—apart from Turkey (as of mid-2016).[35] If capacity mechanisms are put in place in an efficient and timely manner, then gas used for power may start to recover slowly in the late 2010s and post-2020, when much nuclear capacity gets retired and coal starts—hopefully—to decline in the mix.[36]

In this scenario, natural gas demand for power would remain modest and up to 135 bcma by 2020, but grow more rapidly thereafter to reach 140–160 bcma in 2030, depending on how renewable policies, interconnections and coal plants closures evolve.[37] In a theoretical scenario with more ambitious goals on de-carbonisation and assumptions of no power demand increase (thanks to energy efficiency and energy saving plus 2020 and 2030 renewable targets met), gas demand for power would probably remain flat up to 2020 and decline to about 115 bcma in 2030.[38]

3.3 Non-Power Sectors: Limited Expectations

3.3.1 Residential and Commercial Sector

The residential and commercial sector is the largest consuming sector in Europe (41% of total gas demand in 2015[39]). This sector is traditionally less influenced by the economic situation in the short term, but rather by cold temperatures in winter when gas is used for space heating.

However, since 2012, it seems that the reaction to cold spell has been more cautious than just a few years before. Cold temperatures have not raised gas demand by as much as they would have done in the past.[40] This result could be explained by a change of attitude, with people starting their boilers later in the year and/or switching them off earlier at the end of the heating season in addition to lowering the thermostat.

Better insulation of new (and old) houses and metering systems will help to keep gas demand growth in this sector at a low rate.

Small-scale generation from renewable energy sources with solar roof panels, small turbines or heat pumps in the garden for heating and cooling is also being developed in the residential and commercial sector. Self-generated and self-consumed power will have an impact on the gas consumed in this sector but it will also reduce the need for centralised generation and therefore gas for power demand.

The processes using gas for heating could be replaced by processes using electricity such as the use of heat pumps in new buildings (the best example) and also direct heating and heat storage systems. In a low- or zero-energy house, all heating might be covered by the exhaust heat of electric appliances. Both solutions have been used in new buildings in Germany over the last 10 years.

Electrification of heating systems could have important consequences in countries with large changes in temperatures influencing the level of power demand which will peak when temperatures rise or drop to their extremes. This usually happens at times of high pressure, and therefore, when there is little or no wind. Sensitivity to a change in temperatures and additional variations in power demand will create a new need for CCGTs in order to respond rapidly to these changes. For example in France, which has electrified its heating system more than any other country in Europe (aside from Sweden), CCGTs are mostly used to cope with winter variations. These rapid changes in power demand can be enormous as one-degree drop in the mean temperatures creates an extra 2.3 GW load on the system, out of about 5 GW extra load in Europe for every one-degree drop in temperature. As a matter of comparison, the temperature sensitivity of power demand in Germany, the largest European electricity market, is closer to 0.5 GW (0.6 GW in the UK and 0.3 GW in Italy according to the French TSO RTE[41]). The electrification of the heating system could potentially create another niche market for the CCGTs during winters, albeit with low utilisation rates throughout the year and therefore limited impacts on annual demand for gas, except maybe in exceptionally cold winters. Interestingly, higher electricity penetration also means that the higher energy efficiency targets may not necessarily mean lower power consumption.

Governments are also looking at increasing the generation of heat (and cooling) in buildings from renewable energy sources rather than fossil fuel (including natural gas) systems, as stated in their Renewable Energy Action Plans.[42]

As a result, gas consumption growth in the residential and commercial sector is anticipated to be slow despite some switching to gas from oil in the heating sector. This is due to the near saturation of the sector in most European countries, apart maybe from Turkey because of its population growth and its rapid urbanisation and in some smaller markets. However, seasonal variations are expected to remain, with peaks progressively appearing also in the summer.

3.3.2 Industry Sector

Natural gas has a multitude of industrial uses, including providing the base ingredients for various products such as plastic, fertiliser, anti-freeze, and fabrics, and in Europe, it is consumed primarily the chemical industry, followed by non-metallic mineral products, food processing beverages and tobacco and many others, and new applications are being developed frequently. The fall in energy intensity thanks to a shift to light industry instead of heavy industry (shift to less gas-intensive sectors), technological improvements (less gas used in production process) and high gas prices, especially post-2003, are the main factors for gas demand decline in this sector, which still represented about 21% of total gas demand in Europe in 2015.[43]

Still, the sector suffered a significant hit with the 2008/2009 economic crisis. Recovery has been slow, and industrial production was still not back to pre-crisis levels in 2016. Permanent gas demand destruction is likely to have happened in this sector due to factory closures. Competition from regions with lower gas prices, namely North America and the Middle East, means that it is not certain that even in the case of an economic recovery in Europe, industrial gas demand will reach previous levels. Even with lower gas prices expected thanks to the wave of LNG in the second half of the 2010s, it may not be enough to change the relative competitiveness with other regions. Apart from Germany and some Eastern/Southern European countries (including Turkey), no growth is expected in this sector as a result of lower gas prices.

Additional growth will also be curtailed by efficiency policies, even if some sectors such as fertilisers have already implemented energy measures and may not be able to make their production much less energy intensive. Over time, improvements in energy efficiency become more difficult once the "low hanging fruit" has been harvested. As a result, the markets located in Northwestern Europe, for instance, will have limited possibilities to lower gas consumption via improved energy efficiencies, due to past investments and technologies already in place, compared with other regions of Europe.

Another evolution to be expected is the development of decentralised generation by the industries, even small ones. This will not impact the statistics on gas demand for the industrial sector per se, but will change the need for centralised generation, and as a consequence, may lower the future gas needs in power.

3.3.3 Transport Sector

Gas for transport, about 1% of total demand, is expected to be the next key driver for additional demand in Europe. As with the other sectors, natural gas does not have a captive market, and if gas for transport is to grow in Europe or at least in some countries, it will be a policy-driven evolution and as a consequence, may be concentrated in some national markets only, rather than being a true European revolution. While this new market has some potential, demand will not be in the range of the other major sectors such as power, industry or residential and commercial, at least in the period considered in this chapter.[44]

3.4 Conclusions

Gas demand expectations in Europe have been revised downward since the early 2000s. The impacts of energy policies and the effects of the financial and economic crisis of 2009 were largely underestimated. The power sector, "the former key driver for additional demand", has been the main driver for demand decline in the first half of the 2010s as gas-fired plants were sqeezed out of the generation mix, a very different picture from the pre-crisis scenarios.

Natural gas demand in Europe fell from 567 bcm in 2010 to just over 472 bcm in 2015. The power sector is no longer synonym of certain additional gas demand as previously thought in the scenarios designed in the 2000s, and in a majority of countries, it will not be. Nonetheless, most scenarios still expect some additional demand, even in a context of slow economic growth and decarbonisation of the energy sector.

A large share of the renewables in the energy mix needs to be seen as a longer term enduring change even with the revision of support schemes for renewable energy which is happening across Europe. The more the renewables, the less the annual average load factor of thermal generation, especially if electricity demand growth does not pick up again rapidly. Reduced operating hours and an increasing number of plant start-ups and shutdowns in order to balance renewable energy supply is rather new, but power generators with gas-fired capacity will need to adapt to the new role of gas in power generation and create a new business model.

Gas demand growth in the power sector will only happen if (much) more competitive gas prices can help it compete with coal (as the place of nuclear and renewables in the merit order is not affected by changes in fossil fuel prices). The competitiveness of gas prices against coal prices is not expected to change dramatically over the period considered in this paper despite the episode of higher coal prices seen in the second half of 2016. Coal prices are expected to remain low, and the pricing of carbon within the EU ETS is unlikely to climb high enough to make a difference in the dispatch order. Lower gas prices (potentially up to the early 2020s thanks to a global LNG glut) are raising new hopes of gas demand recovery, but to be competitive gas prices would need to drop below $3.5–4/MMBtu in (Western) Europe before switching starts to happen for baseload generation. Additional measures would be needed to trigger a shift to gas in the short term, like in the UK for instance.

However, as coal plants are retired due to the LCPD/IED/EU ETS, this coal-gas prices relationship becomes less and less relevant in most countries in the 2020s. About 50–100 GW of the existing baseload capacity will face closure in our time frame. Much will depend on how the gap between power demand and renewables is filled (and how big the gap is), but this is a possible sign of improvement for gas in the power generation sector on the condition that gas manages its high carbon status and start developing CCS technology in the (close) future.

The most interesting result shown by these scenarios is that European gas demand does not seem to be doomed, however it does not return to 2010 levels: this author expects total gas demand to rise from 472 bcm in 2015 to 482 bcm in 2020 and 512 bcm in 2030.[45] More ambitious decarbonisation policies may limit gas demand growth further and probably keep it close to 460 bcm in 2030.[46] However, at the time of writing, there were no strong signs for this very ambitious scenario to be realised in the time frame considered (Fig. 3.5).

The scenarios represent this author's views at the time of writing the paper (mid- to late 2016, with information available at the time).[47] They will need to be updated as policies/prices/generation mix evolve, but the main conclusion of this research is that the outlook for the gas industry includes the potential for modest future growth at least up to 2030.

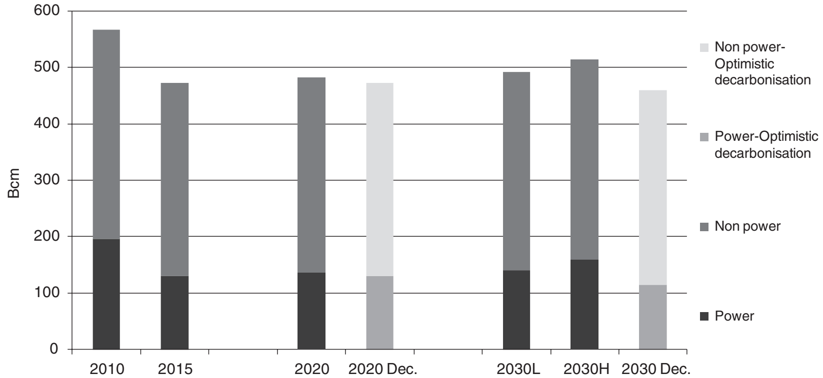

Fig. 3.5 Scenarios for natural gas demand in Europe, by sector (2020 and 2030). *Source* Data for 2010 and 2015: Based on International Energy Agency, *Natural Gas Information, various issues*; Data for 2020 and 2030: Anouk Honoré, "Looking further ahead—What is the outlook for European Gas from 2020–2030?", presentation at Platts conference, Dusseldorf, 28 September 2016

Notes

1. In this chapter, the definition of "Europe" means OECD-Europe, a region which comprises Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.
2. See Anouk Honoré, *European Natural Gas Demand, Supply and pricing, cycles, seasons and the impact of LNG price arbitrage* (Oxford: Oxford: Oxford University Press, 2010), Chap. 1, Sect. 1, for additional information (Honoré 2010).
3. See International Energy Agency, *World Energy Outlook,* several editions (Paris: OECD), for an example.
4. For more details, see Anouk Honoré, *The Outlook for Natural Gas Demand in Europe,* NG87 (Oxford: Oxford Institute for Energy Studies, 2014) (Honoré 2014).
5. International Energy Agency, *Natural Gas Information 2016 Edition* (Paris: OECD, 2016), III.20 (International Energy Agency 2016).

6. 85 bcm below 2008 levels. Source: International Energy Agency, *Natural Gas Information 2016 Edition*.
7. Thanks to the support schemes put in place to reach the EU 2020 targets, more than 50% of the new generation capacity since 2000 has been in some form of renewable energy; this has near zero marginal costs, priority dispatch, and guaranteed access to the grid. Data source: European Wind Energy Association. *Wind in Power*, *2015 European Statistics* (2016).
8. In early January 2011, coal prices (CIF ARA) were $131/mt. In early January 2016, coal prices were $44.5/mt, but had climbed to $66.5/mt in September. Source: Platts, Power in Europe, 10 January 2011, 18 January 2016 and 26 September 2016.
   For more information on coal, EU ETS, and gas prices in the early 2010s, see Anouk Honoré, *The Outlook for Natural Gas Demand in Europe*.
9. The carbon price in the EU ETS has declined from above €25/t in 2008 to €4–8/t since 2013 (time of writing: August 2016).
10. See Anouk Honoré, *European Natural Gas Demand, Supply and Pricing, cycles, seasons and the impact of LNG price arbitrage*, Chap. 3 for more information.
11. New Policy Scenarios for OECD-Europe, in International Energy Agency, *World Energy Outlook 2002* (Paris: OECD, 2002), International Energy Agency, *World Energy Outlook 2010* (Paris: OECD, 2010), International Energy Agency, *World Energy Outlook 2015* (Paris: OECD, 2015) (International Energy Agency 2002, 2010, 2015).
12. International Energy Agency, *Natural Gas Information 2016 Edition*, III.20.
13. Natural gas demand for power has declined faster than total consumption since 2010. In 2015, gas demand for the power sector was almost 40% below 2010—equalling levels not seen since the late 1990s—while total demand declined by 16% over the same period. Sources: International Energy Agency, *Natural Gas Information 2016 Edition* for 2010 data and author's estimate for 2015 data.
14. Data for renewables generation without counting hydro power generation. Source: International Energy Agency, *Electricity information,* several editions (Paris: OECD) and author's estimate for 2015 data in Anouk Honoré, "Demand production vs demand destruction"

(presentation at the Flame Conference, Amsterdam, 11 May 2016) (Honoré 2016).

15. Renewables also benefit from interdiction of significant curtailment, see European Union, "Directive 2009/28/EC, Promotion of the use of energy from renewable sources" (2009) for more information (European Union 2009).
16. With the notable exception of the UK.
17. GDP growth is not expected to be impressive in the period considered in this book, and forecasts in the early 2010s have been revised downwards several times. See Organisation for Economic Co-Operation and Development, *Interim Economic Outlook*. (Paris: OECD, 2016) for additional information (Organisation for Economic Co-Operation and Development 2016).
18. The EU energy savings expected thanks to the (non-binding) 2020 targets will probably reach 17% (maybe as high as 18–19%) by 2020, mostly thanks to the impacts of the financial crisis—and will miss the 20% target by 1–2%. In 2014, the EU countries agreed on a new energy efficiency target post-2020 of 27% (or greater) by 2030.
19. For more information on the EU ETS, see European Commission, "The EU Emissions Trading System (EU ETS), Climate Action", accessed 31 August 2016, http://ec.europa.eu/clima/policies/ets/index_en.htm (European Commission 2016).
20. This would depend on various factors including plant efficiencies, the type of plants in the market (combined cycles, combined heat and power, heat plants), the national mix, the available capacity and interconnections with other markets, and any measures affecting the relationship between these prices—such as the carbon price floor in the UK for instance. For more information on the gas/coal/EU ETS price relationship and additional details at the national level in Europe, see Anouk Honoré, *The Outlook for Natural Gas Demand in Europe*.
21. With highly efficient gas plants and less efficient coal plants, switching may happen at a much lower carbon price (about €/5t CO_2). Source: Anouk Honoré, "Demand production vs demand destruction".
22. See Anne-Sophie Corbeau and David Ledesma, *LNG market in transition: the great reconfiguration* (Oxford: Oxford University Press, 2016) for further details (Corbeau and Ledesma 2016).
23. For more information on the UK carbon price floor, see UK Government. "Carbon price floor: reform". Business tax—policy paper.

Accessed August 31, 2016. https://www.gov.uk/government/publications/carbon-price-floor-reform (UK Government 2016).

24. Anouk Honoré, "Looking further ahead—What is the outlook for European Gas from 2020–2030?", (presentation at the Platts Conference, Dusseldorf, 28 September 2016) (Honoré 2016).
25. Renewable generation is dispatched first, reducing the need for other types of generation.
26. About 320 GW are older than 30 years, 60% of which are fossil fuelled (mostly coal and oil), but there are (in the UK for instance) also some old nuclear plants that may shutdown. Source: Anouk Honoré, *The Outlook for Natural Gas Demand in Europe*.
27. Data source: author's estimates. Source: Anouk Honoré, "Looking further ahead—What is the outlook for European Gas from 2020–2030?". For more details on the LCPD, see European Commission. "Large Combustion Plant Directive". Accessed August 31, 2016. http://ec.europa.eu/environment/archives/industry/stationary/lcp/implementation.htm (European Commission 2016).
28. If the plants are opted out, they will be allowed to run a maximum of 17,500 h between 2016 and 2023 without complying with the new emission limit values, and will then need to be retired.
29. For more details on the IED, see European Commission. "The Industrial Emissions Directive". Accessed 31 August 2016. http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm (European Commission 2016).
30. Author's estimates, see Anouk Honoré, "Demand production vs demand destruction".
31. A phase-out has been decided in Germany (2022), Belgium (2025) and Spain (2028). The role of nuclear is expected to decrease from about 75–50% in the generation mix in France by 2025.
32. Several important gas markets such as Italy, Turkey and Austria do not have nuclear in their energy mix, while some countries (Germany by 2022, Belgium by 2025, Spain in 2028 and Switzerland in 2035) have decided to phase out nuclear. In other countries (for example the UK), plants will be closed, having reached the end of their operating lives. The use of existing plants may also be curtailed following political decisions—such as the position in France where the share of nuclear production in total power generation should be reduced to 50% by 2025 compared to about 75% in 2014.

33. There are only four new reactors under construction in Europe: one in Finland, one in France (both are EPRs of 1600 MW which are experiencing budget and time overruns) and two in Slovakia (each 440 MW). Several countries have expressed interest in building new reactors (for instance the UK, Netherlands, and Sweden) or in introducing nuclear in their mix (Poland, Turkey). However, due to construction lead times, no new reactors (apart from those already under construction) will be operational prior to 2020.
34. This is difficult to estimate as some plants formerly declared mothballed were only shut down for the summer months; others only mothballed part of their total capacity, and some mothballed plants will reopen (such as the SSE Keadby gas-fired power station in the UK for instance).
35. Uncertainty on future load factors and revenues means investment decisions are more difficult; there will be no new conventional thermal plant while there is a merchant risk and zero long-term price visibility.
36. See Anouk Honoré, *The Outlook for Natural Gas Demand in Europe* for details on assumptions and country-by-country scenarios.
37. Anouk Honoré, "Looking further ahead—What is the outlook for European Gas from 2020–2030?".
38. Anouk Honoré, "Looking further ahead—What is the outlook for European Gas from 2020–2030?".
39. Anouk Honoré, "Demand production vs demand destruction".
40. See Anouk Honoré, *The Outlook for Natural Gas Demand in Europe* for more information.
41. For more information, see Réseau de Transport d'Électricité. Accessed August 31, 2016. http://www.rte-france.com/en (Réseau de Transport d'Électricité 2016)
42. European Commission. "renewable energy Action Plans". Accessed 31 August 2016. http://ec.europa.eu/energy/renewables/action_plan_en.htm (European Commission 2016).
43. Anouk Honoré, "Demand production vs demand destruction".
44. For more information, see Christopher Le Fevre, *The prospects for natural gas as a transport fuel in Europe,* NG84 (Oxford: Oxford Institute for Energy Studies, 2014) (Le Fevre 2014).
45. Anouk Honoré, "Looking further ahead—What is the outlook for European Gas from 2020–2030?".

46. Anouk Honoré, "Looking further ahead—What is the outlook for European Gas from 2020–2030?".
47. The main assumptions behind this are no additional power demand between 2015 and 2030 thanks to energy efficiency and energy savings and renewable targets are met.
48. While the region is on the road to the energy transition to a low carbon economy, only the consequences of existing or future policies or measures that can be reasonably expected are considered. Other assumptions involve primarily economic growth, market structure, the competitiveness of the European industry, the competitiveness of gas versus coal in the power sector, available generation capacity and the evolving mix. It is not easy to know which one(s) will be the most important and it has been a different story in each of the various markets. This method created annual scenarios for each sector in each market, and this patchwork was then combined to create a bottom-up regional scenario to the 2030 horizon.

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Author Biography

Anouk Honoré joined the Oxford Institute for Energy Studies in 2004. At the OIES she focuses on the European and South American natural gas markets, building scenarios on demand and supply balances in various countries. She focuses on gas issues with particular emphasis on market fundamentals and policies. Her research also covers power generation. Before joining the OIES, she worked at the International Energy Agency where she focused on China, Latin America and later the IEA members' gas markets.