Title: Projecting EU demand for natural gas to 2030: a meta-analysis

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Abstract

Gas demand projections for the EU27 from a variety of sources are compared. Projected demand varies widely between sources, even when similar rates of economic growth and policy strength are assumed. The divergence is shown to result from differing assumptions concerning future energy intensity, on the one hand, and the future contribution of nuclear power and renewables (RES) to electricity generation on the other. The variation with time of some of these projections is also examined. It is found that the gas demand projected by both the International Energy Agency (IEA) and the European Commission (EC) for 2020 and for 2030 has tended to decrease with each successive projection. This is understandable, since the penetration of RES-E has continued to exceed expectations. However, in an economically depressed, post-Fukushima Europe, estimates of future growth in both RES and nuclear generation may need significant revision. The Energy Efficiency Directive, as agreed by the Council of the

European Union and the European Parliament in April 2012 (Council of the European Union, 2012), will also impact significantly on future gas demand, even though the measures incorporated are weaker than the original proposal. The analysis presented here shows that a "nuclear decline" due to the Fukushima disaster is seen to moderate, rather than reverse, projected demand decay. A significant shortfall in projected RES capacity, if it were to occur, constitutes a potential source of additional gas demand.

Although the emphasis in this paper is on the EU27 as a whole, consideration is given to the regional heterogeneity of each of these impacts. Hence, although aggregate demand growth for the next decade or two is likely to be moderate or (more probably) negative, local demand growth in some regions may be significant. Ensuring adequate access to these specific regions – via interconnection to their EU27 neighbours, and/or directly from extra-EU sources – will therefore be essential. Hence, implementation of the Third Energy Plan should remain a priority.

Introduction

The estimation of future demand for natural gas in the 27 member states of the European Union (henceforth EU27) is of interest to policy makers for a number of reasons. First, the EU is committed to achieving ambitious energy and climate targets by 2020 (Council of the European Union, 2007), and therefore needs to explore policy options that will enable these targets to be achieved. Second, it has begun development of a rolling, ten-year network development plan (TYNDP) for the gas and the electricity networks: the TYNDP for gas needs reliable estimates of long-term future demand in order to ensure appropriate prioritisation of infrastructural developments. Third, the difficulties endured by many member states during the Russia-Ukraine gas dispute in

2009 have heightened EU awareness of its import-dependence. There is now a strong interest in diversifying supply routes and sources, but establishing appropriate entry points and capacity levels requires reliable estimates of future gas demand.

For these and other reasons, the European Commission generates projections from its own resources (primarily based on the PRIMES energy system model), and also makes use of projections from other sources including the International Energy Agency (IEA) and the U.S Energy Information Administration (EIA) (WEPS+ energy system model). In isolation, these projections have inherent value; this paper argues that a comparative analysis between scenarios can offer some useful, additional insight. The paper comprises two main sections, which attempt, respectively, to:

- present an analysis of projections from a variety of sources
- consider the potential impact of some critical developments, not foreseen when most of the projections were prepared, specifically:
  - a shift away from nuclear power in the generation mix, in the aftermath of the Fukushima-Daichi disaster
  - a shortfall in meeting RES targets, due primarily to the on-going financial crisis but exacerbated by increasingly negative sentiment towards nuclear power
  - successful achievement of the EU energy efficiency target inherent in the "20-20-20 by 2020" climate and energy objectives adopted in 2009

A projection is not a forecast: it is predicated on a set of assumptions. Over time, changed circumstances, updated information, policy shifts, etc. may undermine some or all of those assumptions; updated projections are required and generated. So it is with projections of natural gas demand: values are expected to change from one projection to the next. Figure 1 plots projections of EU gas demand prepared by the IEA and the European Commission (EC), for the years 2020 and 2030, as a function of time.

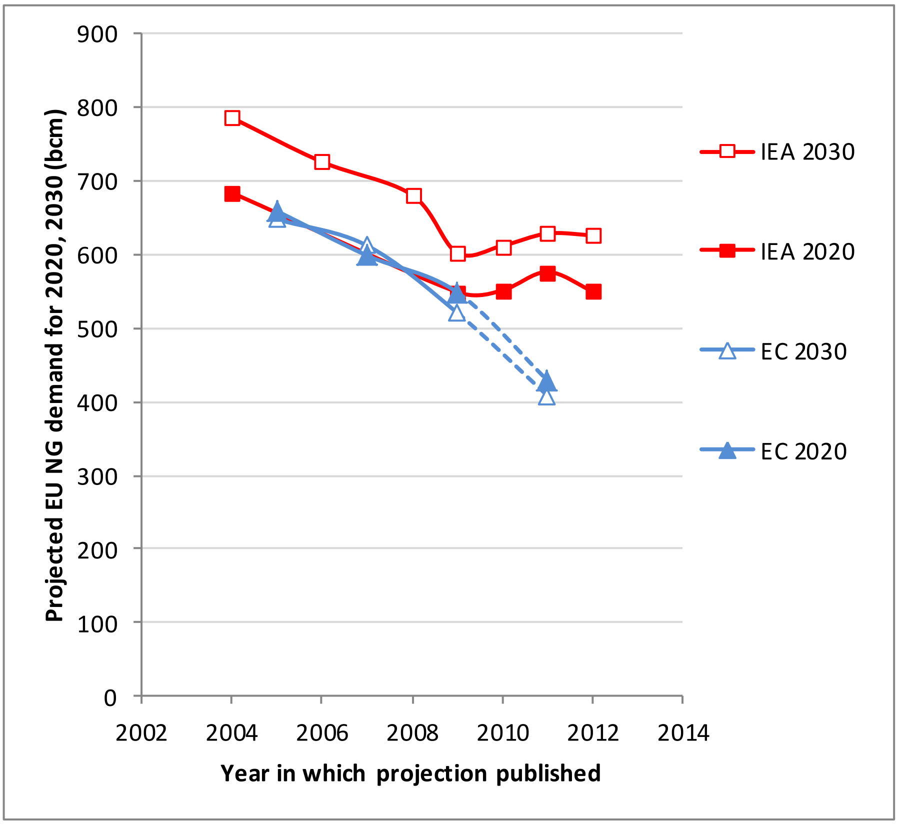


Figure 1 The evolution with time of Baseline projections for EU natural gas consumption in 2020 and in 2030. The dashed lines lead to projected demand if the 20% Energy Efficiency targets are met.

Several interesting features emerge from consideration of Figure 1. First, there is a general downward trend to the projections – estimates of future demand have tended to decrease as we come closer to the target dates. This may reflect the increasing ambition of EU climate and energy policy over that period, and/or the increased price of gas at the EU borders. Second, the more recent IEA projections, following on the outstanding success of shale gas development in the United States and the consequent collapse in the US gas price, have begun to diverge from those of the EC. Third, the IEA projections consistently imply demand growth between 2020 and 2030; EC growth projections for that period are essentially flat. Only time will tell us which set of projections is closer to reality. Clearly, much will depend on markets, and on the formulation, legislation, and implementation of EU energy and climate policy.

Gas demand projections compared

A total of twenty-four gas-demand projections were analysed for this paper. The projections derive from the European Commission (EC), the International Energy Agency (IEA), the U.S. Energy Information Administration (EIA), the European Climate Foundation (ECF), Eurogas – an umbrella organisation representing Europe's major gas companies – and BP plc. Table 1 lists the documents from which the projections were extracted and, for each document, the scenarios considered.

Publication title, citation	Scenarios examined	Moniker
Energy Trends to 2030 (2009 revision) (European Commission, 2010a)	Baseline, Reference	EC Base, EC Ref.
Annex to Energy Efficiency Directive 2011 (European Commission, 2011a)	Annex XIVb	EC EE2020
Energy Roadmap 2050 (European Commission, 2011b)	all	EC Rmap
World Energy Outlook 2012 (International Energy Agency, 2012)	Current Policies, New Policies, 450	IEA CurrentP, IEA NewP, IEA 450
Special Report: Are We Entering A Golden Age of Gas? (International Energy Agency, 2011)	Golden age of gas	IEA GAS
International Energy Outlook 2011[1] (Energy Information Administration, 2010)	Reference, High growth, Low growth	EIA Ref., EIA high, EIA low
Roadmap 2050 (European Climate Foundation, 2010)	Baseline, 80% RES, 60% RES, 40% RES	ECF
Outlook to 2030 (Eurogas, 2010)	Baseline, Environmental	Eurogas Base, Eurogas Env.
Energy Outlook to 2030[2] (BP, 2011)	Baseline	BP Base

Table 1 List of scenarios considered in this paper

Not all documents offer projections explicitly for the EU27: the BP analysis refers to "Europe", whilst the EIA presents data for "OECD Europe". Rather than omit these

[1] The EIA presents figures for OECD Europe, not for the EU27. The equivalent figures for the EU27 presented in this paper were derived by the author.

[2] BP presents figures for Europe, rather than for the EU27. The data presented in this paper has been adjusted by the author – in the same manner applied to the EIA figures – on the assumption that "Europe" denotes "OECD Europe".

projections from the study, equivalent figures for the EU27 were derived by the author for inclusion in this study. This was done by subtracting the estimated consumption of OECD Europe countries that are not members of the EU27 (Iceland, Norway, Switzerland and Turkey), and adding back consumption projections for EU27 member states that are not in the OECD (Bulgaria, Estonia, Latvia, Lithuania, Romania and Slovenia).

Some of the studies analysed here report NG demand data in volumetric terms, as billion cubic metres (bcm) per annum. Others express consumption in terms of energy content, as millions (or thousands) of tonnes of oil equivalent (Mtoe or ktoe). Accurate conversion between these two sets of units is slightly problematic, since the volumetric energy density ($MJ.m^{-3}$) of natural gas varies geographically, and therefore – depending on the supply mix – with time. Moreover, although stated conversion values generally refer to the Gross Calorific Value (GCV) or Higher Heating Value (HHV) of the gas, occasionally the Lower Calorific Value (LCV or LHV) is used[3]. In general, HHV is taken to be 10% greater than LHV. This author's analysis of the values used by IEA, EC, Eurogas, and others produced an average of 38.83 $MJ.m^{-3}$ (HHV), corresponding to 35.30 $MJ.m^{-3}$ (LHV). For clarity, all demand data in this paper is presented in terms of billion cubic metres (bcm) per annum, using these conversion factors where appropriate[4].

[3] In most EC and IEA documents, gas quantities expressed in ktoe or Mtoe are based on LCV; gas quantities expressed in bcm are based on GCV (HHV). 1 Mtoe = 41.868 PJ. Hence, using the HHV value of 38.83 $MJ.m^{-3}$, conversion from Mtoe (LCV) to bcm (HHV) = [41.868 * 1.1 / 38.83] = 1.186 bcm per Mtoe (LCV). The corresponding factor for the reverse conversion is [1/ 1.186] = 0.843 Mtoe (LCV) per bcm. These conversion factors were used for all the data presented in this paper.

[4] Gas is traded and used on the basis of its energy content. Therefore, where a reference provides data as Mtoe and as bcm, the Mtoe values were used to calculate equivalent bcm using this conversion factor: hence, the bcm data presented in this paper may not always match values in the original reference.

Summary of projections

Figure 2 illustrates the true historic consumption of the EU member states since 1998, and the wide disparity in projected future gas demand amongst the various scenarios. The difference between the highest and lowest projection for 2020 is 190 bcm; for 2030 the difference increases to 248 bcm. These values are clearly significant when compared to a total demand in 2010 of 537 bcm. Equally striking is that about half of the projections expect demand to stagnate at, or decline from, 2010 levels, whilst the other half anticipate significant growth in demand.

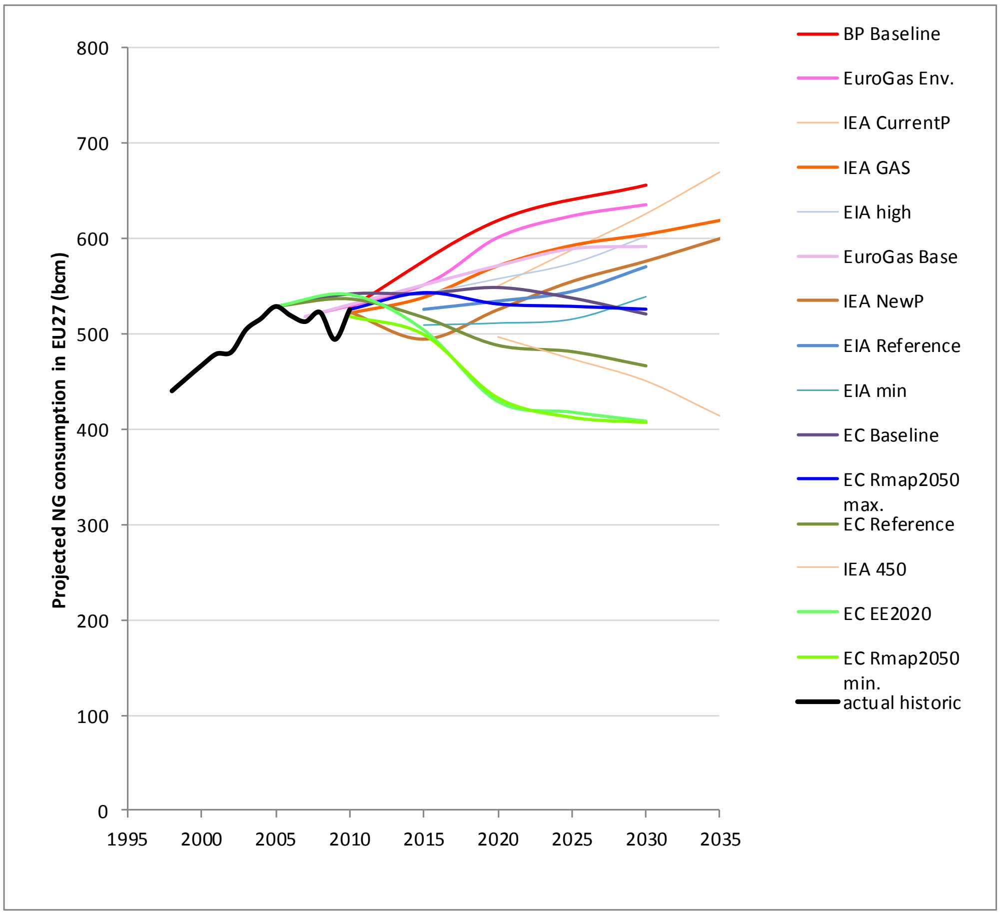
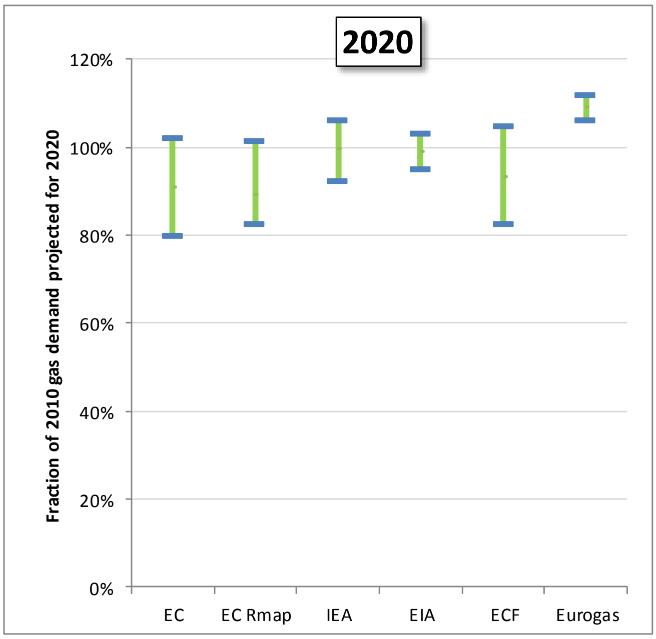


Figure 2 Projected EU27 gas demand vs time, for a range of scenarios.

The projections in Figure 2 come from a variety of sources, as indicated in Table 1. It is instructive to look at the range of demand projections from sources where data from more than one scenario is available. This data is presented in Figure 3, for 2020 and for 2030; in order to give a sense of proportion, the demand relative to 2010, rather than the absolute value, is presented.



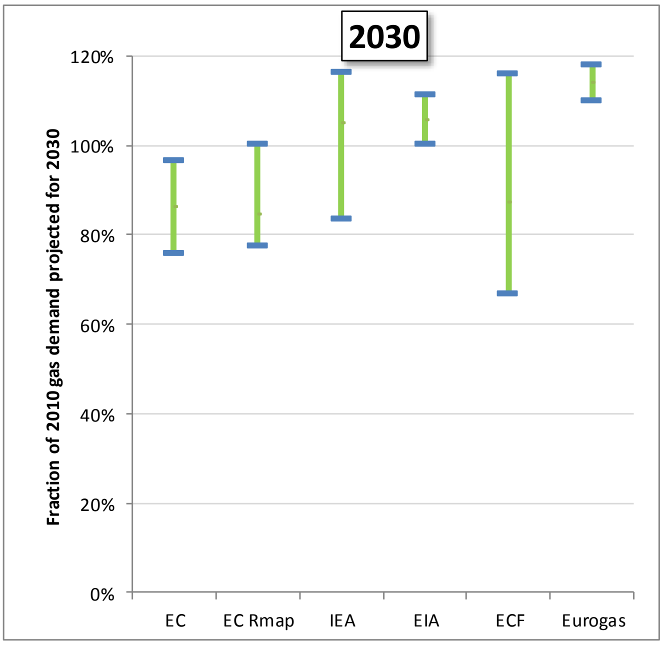


Figure 3 Range of gas demand projected (relative to 2010), in selected scenarios, for 2020 and for 2030.

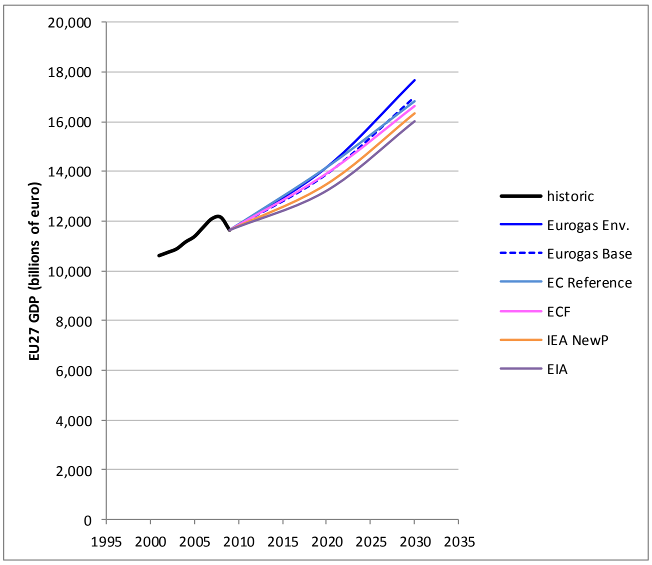
For 2020, both EIA and Eurogas project gas demand to increase; their various scenarios are distinguished by the magnitude of that projected increase. Both offer very similar upper and lower projections. The EC, IEA, and ECF, on the other hand, present scenarios in which gas demand may increase or decrease. The upper and lower bounds of the EC and ECF projections in 2020 are remarkably similar, with the IEA lower bound being somewhat less optimistic than these two; that is consistent with the more conservative policy assumptions associated with the IEA scenarios (see Table 2). It is also clear that the range of demand values projected in Energy Roadmap 2050 (European Commission, 2011c) is similar to that analysed in Energy Trends to 2030 (European Commission, 2010). These two sets of projections will not, therefore, be treated separately in this paper; the later set of projections is implicitly included whenever reference is made to EC projections.

Why do the projections differ so markedly?

In general, energy consumption exhibits a high, positive correlation with GDP. The models used to derive the scenarios analysed here, all use GDP as an input to, rather than an output from, the model. In general, therefore, differences in projected demand for natural gas between scenarios may be due to:

- differing assumptions concerning GDP growth,
- differences in the assumed energy-intensity of GDP, or
- differences in the projected gas-intensity of the energy mix.

Table 2 lists the principal economic and policy assumptions associated with each of the scenarios analysed here. With the exception of the EIA Low Growth scenario, economic assumptions are broadly similar across scenarios – and appear somewhat optimistic from the perspective of mid-2012. The projected evolution of GDP with time, and the correlation between projected GDP and projected consumption of natural gas, are plotted in Figure 4. It is evident from Figure 4 that the correlation between GDP and gas consumption across scenarios is essentially non-existent, and that the differences in projected consumption are not, therefore, due to differences in projected GDP growth.



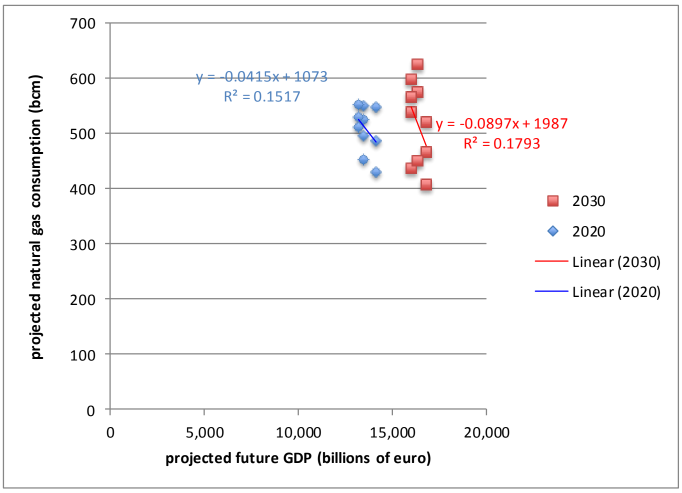


Figure 4 Projected GDP vs time for the main EC, IEA, and EIA scenarios; and projected gas consumption vs projected GDP, with correlation statistics.

A closer examination of Table 2 reveals that the scenarios are distinguished more by assumptions about Policy, than by assumptions concerning economic growth. The policies themselves fall into two broad categories: those intended to reduce the carbon-intensity of energy consumption, and those intended to reduce the absolute level of consumption. Policies aimed at the former objective involve either increased penetration of renewables, increased nuclear power generation, or some combination of the two. Because a substantial fraction of renewable energy is focused on electricity generation, and since the efficiency with which (primary) renewable energy is converted to (final) electrical energy is generally very high, increased penetration of renewables has the effect of improving the (primary) energy-intensity of GDP.

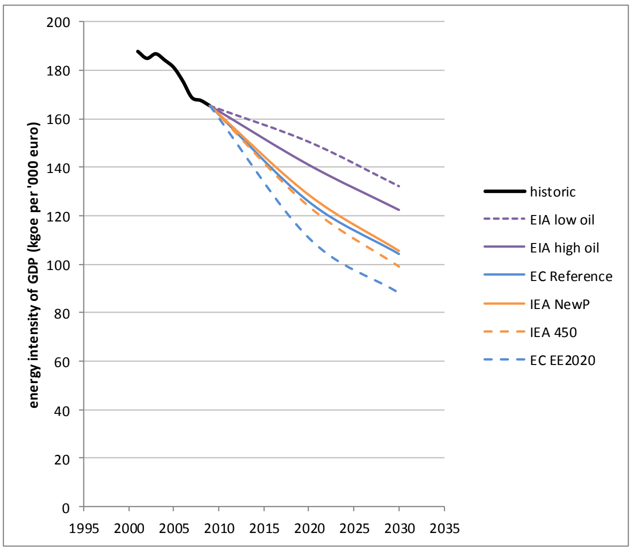
For a given level of GDP therefore, if the structure of the non-renewable sector remains unchanged, increased penetration of renewables will tend to decrease primary energy demand as well as the absolute consumption of whatever gas it displaces. Natural gas consumption will therefore tend to correlate positively with energy-intensity of GDP, and negatively with penetration of renewables. Exogenous assumptions concerning the evolution of energy efficiency in the domestic, commercial, and industrial sectors will clearly exert a significant influence also. The EC EE2020 scenario distinguishes itself from most others considered in this paper by incorporating the aggressive energy efficiency targets agreed by the European Council in Spring 2007 (Council of the European Union, 2007), and formally adopted in December 2008.

Source	Scenario	Annual GDP growth	Policy assumptions
EC	Baseline	2010-2020: 2.2% 2020-2030: 1.7%	Current policies (implemented up to April 2009)
	Reference		Policies adopted up to December 2009; national targets established under the RE and GHG Directives 2009/28/EC and 2009/406/EC are achieved
	Energy Efficiency		As Reference, plus measures needed to meet EU target of 20% improvement in energy efficiency by 2020
	Energy Roadmap 2050	2010-2030: 1.7%	As Energy Efficiency, plus ENTSO-e TYNDP, plus Nuclear Safety, Waste Management, and Energy Taxation Directives
IEA	Current Policies	2010-2020: 1.7% 2020-2030: 1.9%	Policies formally adopted by mid-2010
	New Policies		As Current Policies, plus broad commitments already announced, plus cautious implementation of GHG pledges
	450		As New Policies, plus implementation of high end of GHG commitments, plus stronger policies after 2020.
EIA	Reference	OECD Europe: 2007-2020: 1.5% 2020-2030: 1.9%	Existing policies only – does not include prospective legislation or policies Germany, Italy, and Belgium embrace nuclear power
	High growth	2007-2020: 2.0% 2020-2030: 2.4%	As Reference, but annual GDP growth rate 0.5% higher
	Low growth	2007-2020:	As Reference, but annual GDP growth rate

		1.0% 2020-2030: 1.4%	0.5% lower
ECF	Reference	2010-2030: 1.8%	
	Decarbonised	2010-2014: 1.7% 2015- 2030: 1.9%	
Eurogas	Baseline	2.0%	
	Environmental	> 2.0% (assumed 2.2%)	
BP	Baseline	Not stated	

Table 2 Summary of key economic and policy assumptions, per scenario

Figure 5 plots the projected evolution of primary energy-intensity with time for some of the key scenarios, and the correlation between energy-intensity and consumption of natural gas. It is apparent that the EC Reference and IEA policies project a continuing decline in energy-intensity, at a rate more or less in line with historical observations. The EE2020 scenario projects a more rapid decrease, particularly in the period to 2020. A clear, if not particularly strong, correlation is evident between gas consumption and primary energy-intensity.



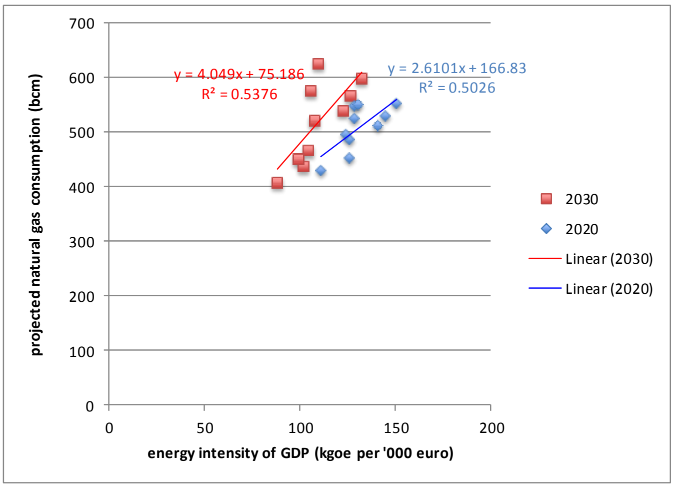


Figure 5 Projected primary-energy-intensity of GDP vs time for the main EC, IEA, and EIA scenarios; and projected gas consumption vs projected energy-intensity of GDP, with correlation statistics.

The third potential reason for the widely differing projection of gas demand concerns differences in the assumed gas-intensity of the energy mix between scenarios. Consideration of Figure 6 offers some insight into these assumptions for the key EC and IEA scenarios. Each graph in Figure 6 plots the projected change in Gross Inland Consumption (GIC) of all fuels relative to 2010. Consider first the changes projected for 2020. In the EC Baseline scenario, a small (c. 60 Mtoe, 3%) increase in GIC is projected.

Renewables displace a small amount of coal, oil, and nuclear energy; additional RES, and some additional gas, are used to satisfy the projected increase in GIC. In the EC Reference scenario, on the other hand, the net increase in GIC is close to zero. A larger increase in renewables is projected to displace all three fossil fuels and some nuclear energy; the result is a slight increase in GIC, and a modest decrease in gas consumption. The EC EE2020 scenario differs significantly from these two. It projects a significant decrease (c. 200 Mtoe, 11%) in GIC by 2020. Renewables increase by about the same amount as in the Reference scenario and, due to the reduced GIC, displace significant amounts of all three fossil fuels and substantial nuclear generation.

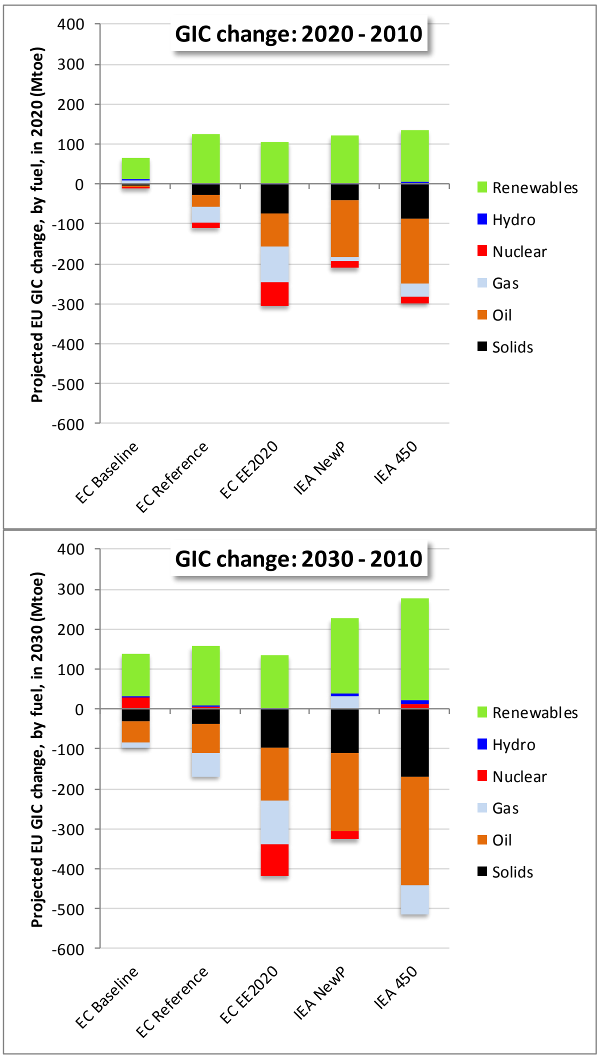


Figure 6 Projected change in Gross Inland Consumption, for selected scenarios

The IEA projections offer alternative scenarios. Under "New Policies" a decrease (c. 90 Mtoe, 5%) in GIC is projected for 2020. Nonetheless, renewables increase by 93% relative to 2010 levels: about the same as in the EC Reference scenario. Under "New Policies" assumptions, these renewables displace mainly oil and coal; gas and nuclear are almost unchanged. In the more aggressive "450" scenario, GIC decreases by just over 9%; renewables increase by 105% relative to 2010 – similar to the 100% increase projected in EE2020 – and displace additional coal and oil, plus some gas and nuclear.

It is interesting to note that, for both 2020 and 2030, an overall decrease in GIC coupled to an increase in RES is projected in all except the EC Baseline scenario. The inevitable consequence is a projected decrease in demand for fossil and, to a lesser extent, nuclear energy in 2020 and in 2030 in these scenarios.

Figure 7 plots the projected evolution of gas-intensity with time, and the correlation between gas demand and gas-intensity, for some of the key scenarios. Unsurprisingly, the correlation between gas-intensity and gas demand is reasonably strong. It is also clear that all plotted scenarios, with the exception of IEA New Policies, project gas-intensity to decrease in coming years – a clear reversal of the trend over the past decade.

This reversal is due to the assumption, to varying degrees in the individual scenarios, of increased penetration by renewables and/or nuclear power in the EU27 energy mix. Figure 8 plots the projected percentage change in gas demand relative to 2010, versus the percentage change in GIC, for the main EC and IEA scenarios. Solid symbols denote EC projections, hollow symbols IEA; dashed lines distinguish projections based on the most ambitious policy implementation. Also shown in Figure 8 is a grey line indicating a change in gas demand exactly proportional to a change in GIC.

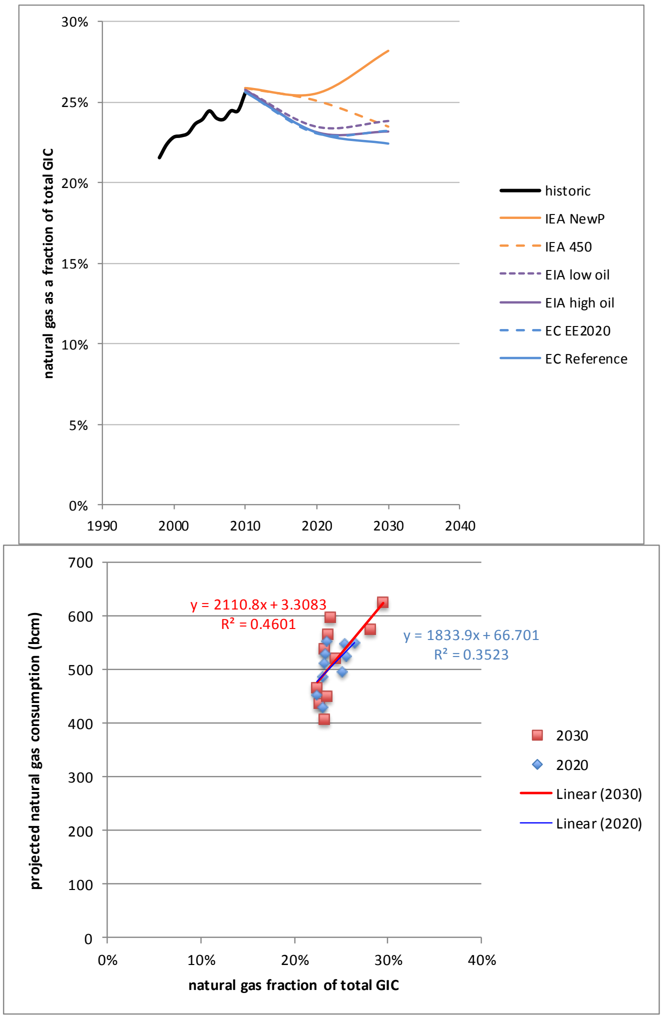


Figure 7 Projected gas-intensity of GIC vs time for the main EC, IEA, and EIA scenarios; and projected gas consumption vs projected gas-intensity of GIC, with correlation statistics.

An interesting observation from Figure 8 is that, in the EC scenarios as policy ambition is increased, gas demand declines more rapidly than GIC: all solid symbols lie below the grey line. Conversely, in all but the most ambitious IEA scenario (IEA 450), GIC decreases more rapidly than natural gas demand (NGD); the hollow symbols lie *above* the grey line.

This is because the EC scenarios generally project the retention of more coal (and therefore less gas) in the energy mix, as noted in Figure 6.

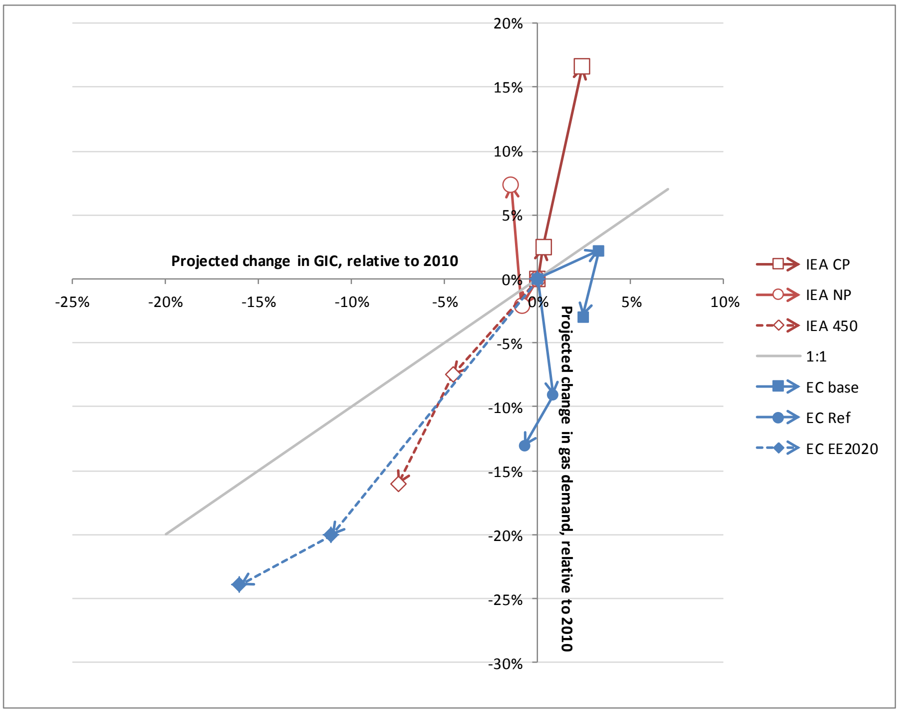


Figure 8 Projected change in gas demand vs projected change in GIC, relative to 2010, for the EC and IEA scenarios. Blue, shaded symbols represent EC projections; red, open symbols represent IEA. The pale grey line (no symbols) indicates a change in gas consumption exactly proportional to the change in GIC.

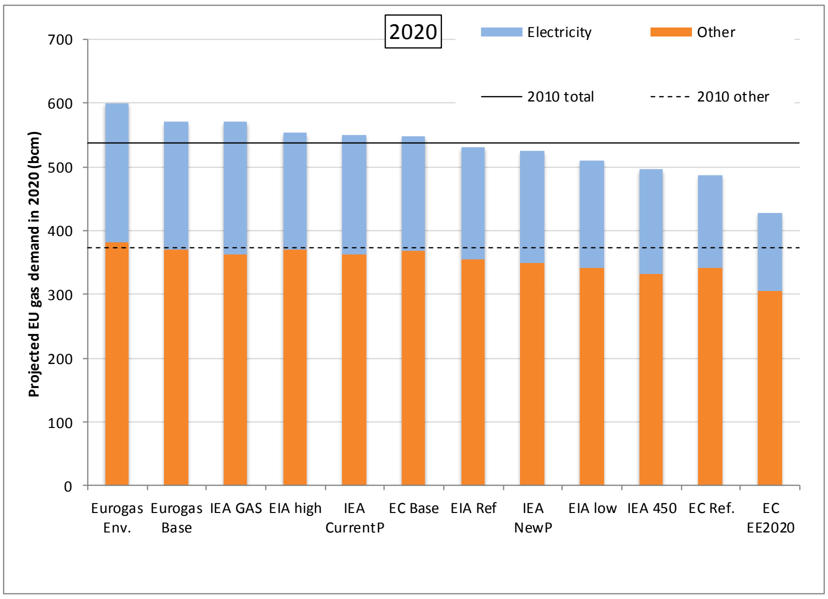
A second point to note is that, in each of the three EC scenarios, both GIC and NG demand decrease in 2030 relative to 2020. In IEA Current Policies *both* GIC and NGD increase in the period from 2020 to 2030; under New Policies GIC remains almost constant, but *NGD increases*. Only in the IEA 450 scenario do both GIC and NGD decrease from 2020 to 2030.

Finally, it is evident from Figure 8 that the cuts in both GIC and NGD projected in the EC EE2020 scenario are substantially deeper than in the most ambitious IEA scenario.

As mentioned above, much of the existing and projected contribution by renewables is associated with electricity generation; with nuclear power it is exclusively so. The degree to which these technologies displace gas will therefore be sensitive to the degree to which gas is used for this purpose. Apart from this application of gas – as a fuel for electricity generating plant – its main use is to supply space or process heat. Substitution of gas in the heating role is considerably more challenging: the only alternative fuel available in many cases is oil, although heating systems based on electricity (e.g. heat pumps), biomass combustion, solar energy or waste heat may – in particular cases – offer a viable alternative.

Figure 9 presents the projected demand split between electricity generation and all other purposes, for the subset of scenarios where this data could be extracted. For reference, the total gas demand for 2010, and the corresponding split between gas use for electricity generation and for other purposes, are also shown. Across all these scenarios, electricity generation is projected to account for 29%-36% of gas demand in 2020, and 29%-39% in 2030. (For comparison, it accounted for 30% in 2010.)

Despite its relatively modest contribution to gas demand, electricity generation is the most significant source of demand variance between scenarios, and will constitute the primary focus of this paper. This is clear from Figure 9, in which it is seen that the projected gas demand for purposes other than electricity generation ("Other") is projected to remain remarkably close to 2010 levels for all but the four lowest demand projections. Across all scenarios in Figure 9, the difference between the highest and the lowest demand projection for 2020 is 172 bcm; of this, 95 bcm (55%) is accounted for by differences in projected demand from the electricity sector, even though that sector accounts for only about 35% of gas demand in 2010. For 2030, the difference is 227 bcm, of which 115 bcm (51%) is due to differences in projected demand for electricity generation.



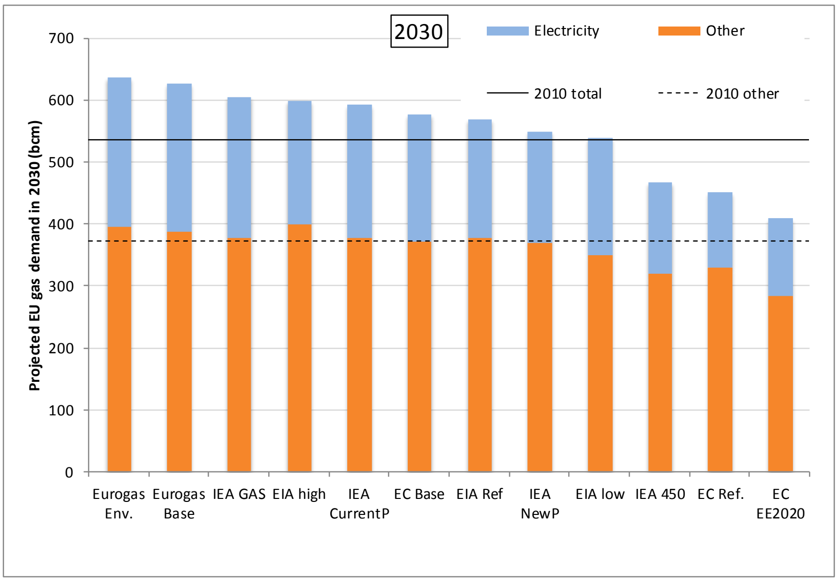


Figure 9 Projected gas demand split, between electricity generation and other purposes, for each of the main scenarios analysed. The EC "Energy Roadmap 2050" scenarios (not shown in this Figure) all lie between "EIA Ref" and "EC EE2020"

The disproportionate contribution of the electricity sector to the variations in projected demand for gas is due to the (relative) ease with which gas can be substituted in power generation – by coal, by nuclear power, or by renewables.

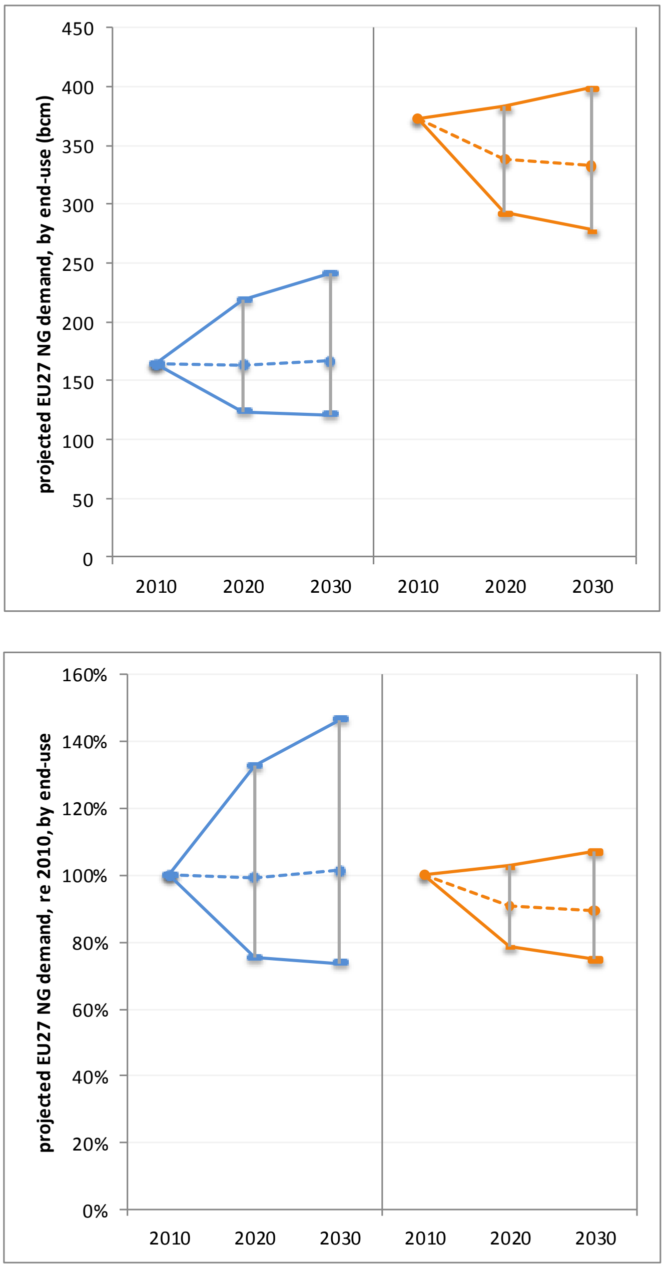


Figure 10 Range of NG demand projections, for electricity generation (blue) and other uses (orange), in 2020 and 2030: absolute volumes in left graph; changes relative to 2010 demand in right graph. Dashed line denotes average of all scenarios analysed.

Where an organisation presents more than one scenario, the “greener” scenario generally projects lower gas demand from the electricity sector – a consequence of increased RES-E generation. The exception (perhaps unsurprisingly) is Eurogas, whose Environmental scenario projects an *increase* in demand for gas-fired generation. Although out of line with other “green” projections, this conclusion is not inherently unreasonable if, as discussed later in this paper, future production from RES-E and nuclear sources fails to meet expectations. Differing projections of demand for gas from the electricity sector are due, essentially, to differing assumptions concerning the extent to which:

a) fossil fuels will be displaced by renewables and/or nuclear generation, and

b) gas will displace other fossil fuels for electricity generation

Consideration of some IEA and EC scenarios highlights this point – see Figure 11. The IEA “New Policies” scenario projects gas use for electricity generation to be 21% higher in 2020, and 46% higher in 2030, than the EC Reference scenario. Gas demand projections from other sectors are only 4% and 18%, respectively, above the EC projections.

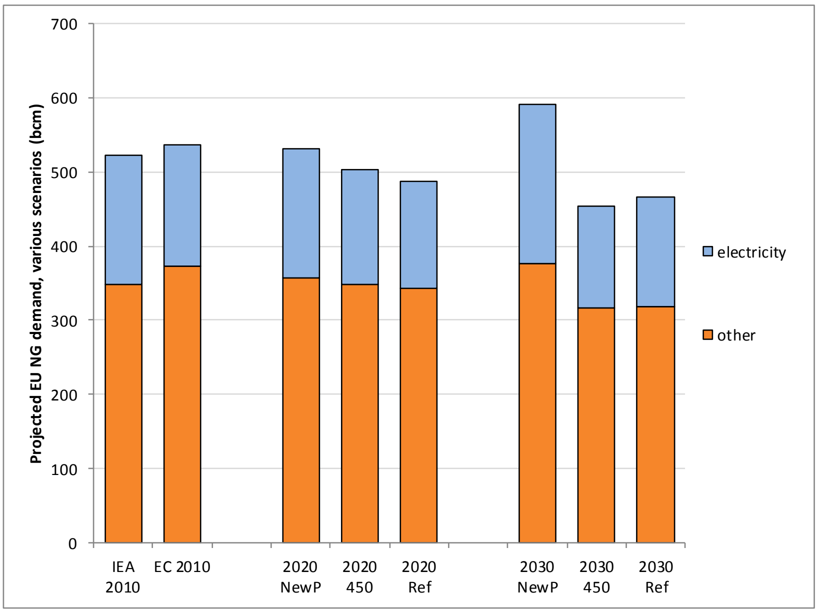
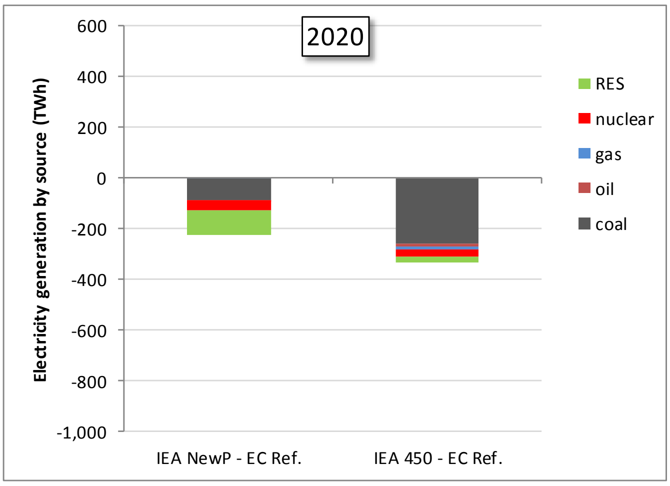


Figure 11 Apportionment of gas demand, between electricity generation and "other": currently; as projected for 2020; and as projected for 2030.

This discrepancy arises from two sources: the first is that the EC assumes a higher efficiency for gas-fired generation – 50% versus 43% for the IEA. The second source is revealed in Figure 12, which displays the difference in projected generation, by fuel type, between the two main IEA scenarios and the EC Reference scenario. It is evident that, in both 2020 and 2030, the EC projects a higher level of coal-fired generation than either of the IEA scenarios; if the current (2012) price spread between gas and coal continues, such an outcome seems highly plausible.



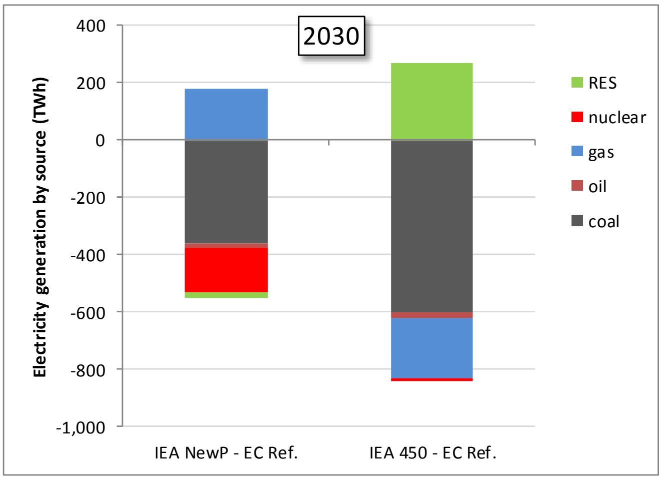


Figure 12 Differences in the projected electricity generation mix, between the EC Reference scenario and the IEA "New Policies" and "450" scenarios, for 2020 and 2030.

In summary, the disparities in NG demand projections between the various scenarios are due to differing assumptions concerning one or more of the following:

- the generation mix in the electricity sector
- renewables penetration in the energy mix
- energy efficiency / energy intensity

These three factors are seen to be primary determinants of future NG demand. The next section of the paper will consider the potential impact on future NG demand of two substantial, unforeseen changes to these factors: the nuclear meltdown in Fukushima-Daichi in 2011, and the continuing financial crisis in the West.

Unanticipated change 1: A post-Fukushima decline in nuclear generation

High impact, low probability (HILP) events – such as the Japanese earthquake and tsunami in February 2011 – can lead to step changes in both policies and markets. In the case of the Japanese disaster, a large and possibly persistent change in sentiment towards nuclear power has emerged, that may have far-reaching consequences for gas demand in electricity generation. Analysis of historical data (European commission, 2010) reveals that the top five EU-27 economies – Germany, France, UK, Italy, and Spain – generate 66% of EU electricity, and 75% of nuclear electricity. The following analysis will focus primarily, therefore, on these five economies. The analysis begins with a review of current (2012) nuclear generation, and the changes assumed in the EC Reference scenario.

Current situation (2012)

From Figure 13 it is clear that the top five economies differ significantly in their level of dependence on nuclear generation, and on the projected evolution of that dependence. Of the five, France is by far the most reliant on nuclear power and, in the EC Reference scenario, is expected to remain so up to 2030. Nonetheless, the addition of RES is projected to reduce the fraction – though not the absolute amount – of electricity derived from this source, from almost 80% currently to about 67% in 2030. However, President Hollande's launch, in November 2012, of a national debate on cutting nuclear energy to 50% by 2025 (Reuters, 2012), means this assumption may need significant revision. Germany and Spain both exhibit moderate nuclear dependence, but have declared policies of phasing out most nuclear generation by 2020, and by 2030, respectively. UK dependence, modest in 2010, is expected to increase by 2030 to help meet ambitious targets for CO_2-intensity of generation. In 2008, Italy – with zero indigenous nuclear generation when the scenario was constructed – declared its intention to add significant nuclear capacity to the generation mix, with a target of producing about 25% of its electricity from this source by 2030. Although that decision has since been overturned in the 2011 Italian referendum (BBC News, 2011c), its implementation was assumed for EC Reference scenario published in 2010.

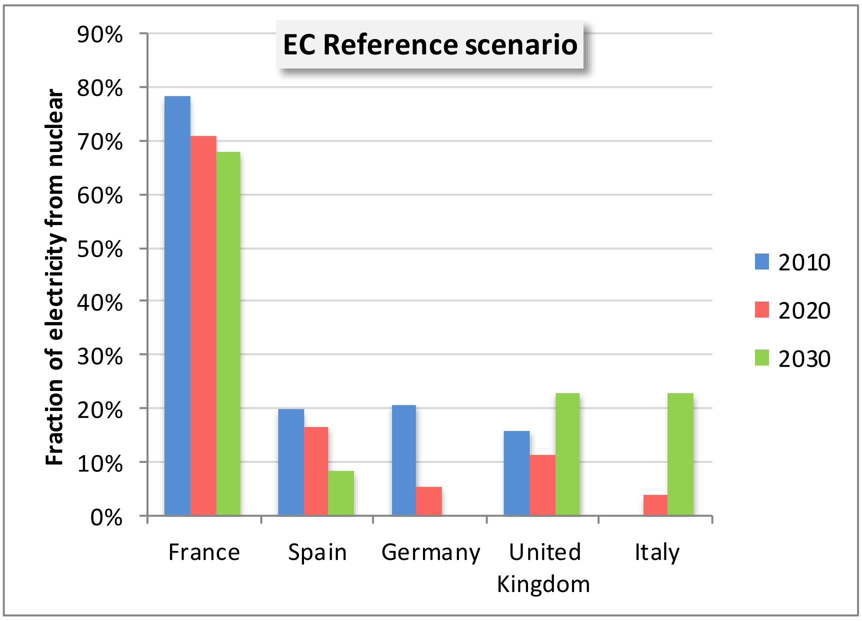


Figure 13 Fraction of electricity derived from nuclear plant, for the "big five" EU economies, under the EC Reference scenario

Figure 14 indicates the absolute change in electricity generation projected for the EC Reference scenario for each of these five economies, by primary energy source, for 2020 and for 2030. From the figure it is clear that only Italy is projected to increase nuclear generation significantly, with most of that increase due to occur after 2020.

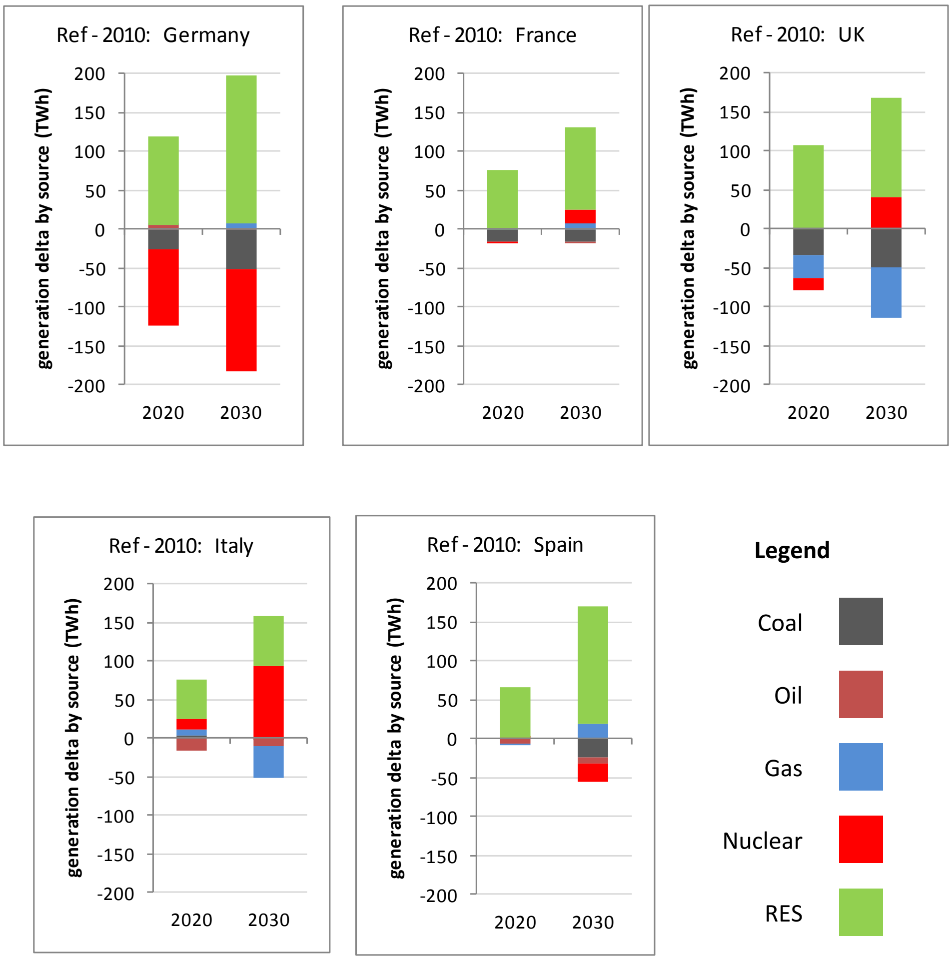


Figure 14 Change in electricity generation relative to 2010, by fuel source, for the "big five" economies, under the EC Reference scenario

In May 2011, as a direct consequence of the Fukushima accident, the German government announced its intention to phase out all nuclear power by 2022 (Wall Street Journal, 2011a). Both the "Baseline" and "Reference" scenarios of the European Commission's 2009 projections already assume that the nuclear phase-out occurs by 2022, so that the May 2011 decision has relatively little bearing on the German gas demand projected in those scenarios. However, it is clear from Figure 14 that, in the Reference scenario, the displaced nuclear generation is to be compensated entirely using RES. As revealed below, that assumption embodies significant implications for gas demand if the projected increase in RES capacity fails to match expectations.

As of September 2012, only three new nuclear reactors are actually under construction within the EU. Flamanville 3 in France, a 1,630 MWe EPR reactor, is now scheduled for grid connection in 2016 following a series of delays and cost over-runs (World Nuclear News, 2011c). Olkiluoto 3 in Finland, another 1,630 MWe Areva EPR plant, also suffered significant delays and cost increases during construction, but is now scheduled for grid connection in 2013 (World Nuclear Association Reactor Database). Mochovce 3 and 4 in the Slovak Republic, PWR reactors of 390 MWe each, are scheduled to commence operation in 2013.

The “nuclear decline” scenario

Given the uncertainties outlined above, it is at least possible that the levels of nuclear generation envisaged in the projections being discussed will not be realised – henceforth denoted the “nuclear decline” scenario. In that case, demand for gas- and coal-fired generation would increase in order to fill the base-load gap. The assumptions made in the “nuclear decline” scenario are as follows:

- No nuclear generation in Italy
- Germany phases out all nuclear generation before 2020
- With the exception of the three sites listed above, no *additional* nuclear capacity is installed up to 2030, although replacement of existing capacity proceeds where this is already planned (e.g. UK)
- Planned plant closures follow those outlined in the EC Reference scenario

- The generation deficit – i.e. the difference in nuclear generation between this scenario and the EC Reference scenario – is compensated entirely using gas-fired CCGT with thermal efficiency of 50%

The effect of the final assumption is to produce a "worst case" (i.e. maximum gas demand) scenario; it therefore sets an upper bound on the increased gas demand that might plausibly be expected to arise should the prior assumptions prove correct.

The size of the deficit, and the implied additional gas demand required to power the replacement CCGT, is presented in Table 3 for the EC Reference scenario, and in Table 4 for the IEA and EC scenarios. The size of this increased gas requirement, in relation to overall EU27 gas demand, is presented in Figure 15.

	Generation deficit (TWh)		**Additional gas demand (bcm)**	
	2020	**2030**	**2020**	**2030**
France	*9.2*	*0.0*	1.9	0.0
Germany	*34.6*	*0.0*	7.1	0.0
Italy	*13.7*	*93.3*	2.8	19.0
Spain	*0.0*	*0.0*	0.0	0.0
United Kingdom	*0.0*	*53.8*	0.0	11.0
Others	*43.5*	*91.7*	8.9	18.7
Total	**101.0**	**238.7**	**20.6**	**48.7**

Table 3 Generation deficit arising in the EC Reference scenario, for EU 27 and for selected regions, in the case of "nuclear decline".

Scenario	Nuclear generation (TWh)			Generation deficit (TWh)		Additional gas required (bcm)	
	2009/10	2020	2030	2020	2030	2020	2030
IEA 450	894	893	1,045	109	301	22	61
IEA NewP	894	885	882	101	138	21	28
EC Ref	926	885	982	101	239	21	49
EC nuclear decline	926	784	744				

Table 4 Projected nuclear generation for selected scenarios; resulting generation deficit in the case of the "nuclear decline" scenario; and implied additional gas requirement for replacement CCGT generation

One subtlety of the data presented in Table 4 is that the nuclear generation projected for 2030 in the EC Reference scenario is significantly higher than in IEA New Policies, despite the fact that the projected nuclear capacity is 10% lower. This implies a capacity factor of 91% for nuclear plant in 2030 under the EC Reference scenario, which is rather high. Since the additional gas requirement is based on the generation deficit, rather than a capacity deficit, this has no direct bearing on the calculation however.

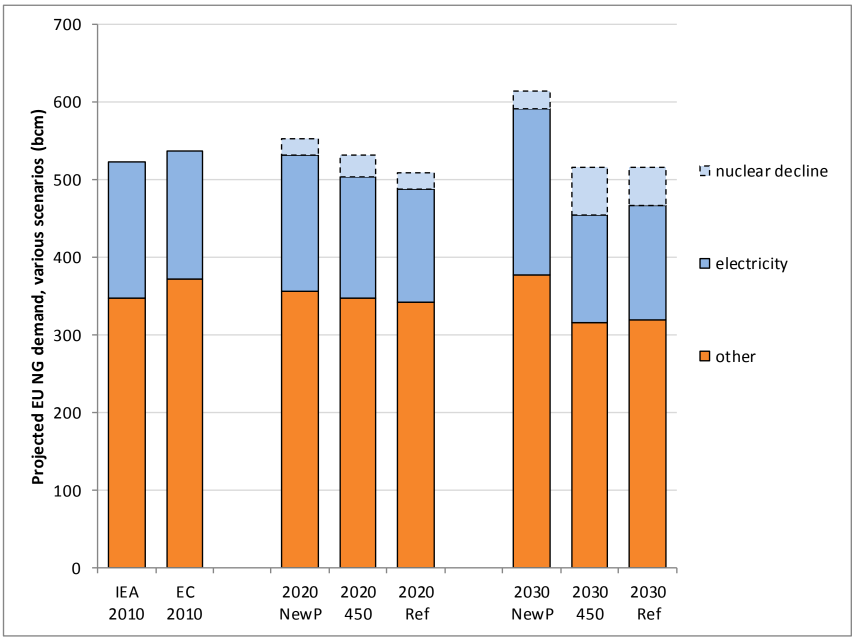


Figure 15 Impact of a "nuclear decline" on gas demand in the selected EC and IEA scenarios

Figure 15 indicates that, even under this relatively taxing modification of the principal EC and IEA scenarios, the impact on EU27 gas demand is generally quite modest (4%-10%). An exception is provided by the IEA 450 scenario in 2030 where, due to the high reliance of the scenario on nuclear generation, gas demand would increase by almost 20% if the "nuclear decline" were to occur.

Unanticipated change 2: Failure to meet RES targets

In its meeting on 8-9 March 2007, the European Council agreed three high-level targets related to energy use and climate change, to be achieved by 2020 (Council of the European Union, 2007):

- reduce EU energy consumption (GIC) by 20% relative to business-as-usual projections for 2020

- set a binding target of a 20% share of renewable energies in overall EU energy consumption (GFC) by 2020
- achieve at least a 20 % reduction of greenhouse gas emissions by 2020 compared to 1990

Arising from this decision, Directive 2009/28/EC sets binding, individual, RE targets for each member state, such that the overall EU target of 20% can be met (European Commission, 2009). The Directive classifies RE into three broad categories, associated with electricity generation (RES-E), heating and cooling (RES-H/C), and transport (RES-T). The Directive also stipulates that each member state must submit to the Commission, by June 2010, a National Renewable Energy Action Plan (NREAP) in which they specify national targets for the share of RES in each of the three categories, and the measures to be taken to achieve those targets. They must also submit, by 31 December 2011 and every two years thereafter, a report on progress towards the targets.

The individual NREAPs may be examined on the Commission website, and a synthesis of the figures contained therein – at both national and EU level – has been prepared (Beurskens and Hekkenberg, 2011). Examination of the data reveals that EU27 member states plan to *add* approximately 129 GW of wind generation, 60 GW of solar capacity, and 42 GW of other RES-E between 2010 and 2020. On the heating and cooling side, an additional 45 Mtoe of renewable energy (RES-H/C) is to be supplied, of which almost two thirds will come from biomass. These substantial numbers represent a doubling of existing RES capacity; given the capital-intensity of most RES technologies, they also imply the need for very substantial investment.

However, at least three significant factors are exerting downward pressure on the rate of growth in RES, and may lead to the EU target of 20% RES in GFC by 2020 being missed. First, the on-going Western financial crisis forms the backdrop to a difficult and uncertain investment environment: credit is in short supply (EFMA, 2011), and investors are increasingly circumspect (Ernst & Young, 2011). Second, the political turmoil in the Middle-East and North Africa (MENA) is maintaining oil prices close to historic highs (The Economist, 2011), (US Energy Information Administration, 2013). Although high oil prices may appear to favour investment in oil-independent RES, they also have the effect of increasing the associated setup costs. The third factor, ironically perhaps, is the post-Fukushima apathy towards nuclear power.

The German decision to phase out all nuclear power by 2022 (German Energy Blog, 2011a), for instance, may have significant implications for government revenue, and hence for its capacity to support investment in renewables. In exchange for extensions to the operating lives of Germany's existing nuclear power plant, operators had agreed in 2010 to a "fuel-rod tax" and to additional payments into an Energy and Climate Fund. The fuel-rod tax was intended to provide government revenue of €2.3 bn per annum from 2011-2016; payments into the Energy and Climate fund would provide an additional €0.2 – 0.3 bn each year from 2011-16, and about €1 bn per year thereafter (German Energy Blog, 2010). Although the legislative package for the "energy turnaround" reverses the life extension plans, it retains the nuclear fuel-rod tax (German Energy Blog, 2011a). However, all three nuclear plant operators – E.ON AG, RWE AG and EnBW AG – are taking legal action against the tax (German Energy Blog, 2011b), so it remains to be seen whether or not this source of revenue will materialise. It has also been decided that, in future, all revenues from auctions of CO_2 emission allowances will flow into the Energy and Climate Change Fund (Federal Ministry of Finance, 2011). Nonetheless, it is clear that the decision to phase out nuclear power is likely to reduce the funds available for government to support investment in RES. Simultaneously, it increases the need to invest in substitute, dispatchable, power plant – much of which will be fired with fossil fuels as discussed above (Renewable Energy World, 2011a), (Umweltbundesamt, 2011).

Moreover, high oil prices increase the pressure on EU governments to facilitate the supply of energy services at the lowest possible cost. In that context, the favourable feed-in-tariff (FIT) rates being offered to RES-E – which have catalysed investment in the sector (e.g. Algappan et al, 2011)– are coming under intense scrutiny. Germany (Solas Power, 2011a), Spain (Solas Power, 2011b), Holland (European Energy Review, 2011), and Italy (McDermott Will & Emery, 2011) have announced substantial reductions in FIT rates for future RES. Although Germany decided in June 2011 to defer the proposed mid-2011 FIT cut for photovoltaic systems – following weak installation figures – they plan to continue with subsequent FIT decreases (Solar Industry, 2011). Ireland's Economic and Social Research Institute (ESRI), a government-funded economic think-tank, asserted in April 2011 that the FIT for technologies other than onshore wind should be ended (Fitzgerald, 2011).

This combination – restricted flow of investment coupled with lower returns from RES-E and increased need for investment in dispatchable power – is likely to exert significant downward pressure on the RES-E investment rate. These factors have loomed over the investment landscape since 2008, are likely to persist into 2013, and might possibly extend for several years beyond that. By hampering economic growth, the financial crisis and sustained high oil prices may also depress energy demand, and thereby reduce the absolute amount of RES required to achieve the EU targets: examination of Eurostat data (Eurostat 2010, 2012) reveals that both Gross and Final energy consumption decreased between 2007 and 2010, the latest year for which figures are available. Notwithstanding this reduction in energy requirement however, it is at least plausible that – in the circumstances outlined above – RES-E installations may fall significantly short of the targets submitted under the National Renewable Energy Action Plans (NREAPs), and projected in the "EC Reference" and "IEA New Policies" scenarios.

Such a deficit would need to be compensated using some combination of coal-, oil-, gas-, or nuclear-powered generation. Of these, oil is the least likely candidate for obvious reasons. Coal also constitutes an unattractive option: notwithstanding the substantial investments in Carbon Capture and Storage (CCS), made by the EU under the European Energy Programme for Recovery (EEPR) and by the US, the lack of evident progress in commercialisation and implementation of CCS suggests that CCS-equipped coal generation would be physically incapable of making a substantial contribution by 2020. The likelihood of new-build coal plant achieving social or political acceptance in the absence of CCS seems remote indeed, and with significant uncertainty surrounding the likely future price of CO2 under the EU-ETS, finding investors for such a plant might prove difficult in any event. Increasing the capacity factor of existing coal plants, as has happened in Germany in 2011-2012 (Bloomberg, 2012), provides a short-term solution, but is difficult to reconcile with longer-term objectives relating to either GHG emissions or to energy efficiency.

The increasing concerns over nuclear power following events at Fukushima-Daichi, plus the long lead times required to permit, construct, and commission nuclear plant, mean that new-build nuclear generation would be unable to contribute significantly by 2020 even if – and it's a big if – it were to achieve social, political, and investor acceptance before then. Notwithstanding Poland's enthusiasm for (Nuclear Power Daily, 2011), and France's continued reliance (BBC News, 2011a) on the technology, the decisions by Germany (Wall Street Journal, 2011a) and Switzerland (New York Times, 2011) to phase out nuclear power over the next decade or two, and Italy's rejection of nuclear generation in the referendum of 12-13 June 2011 (BBC News, 2011b) are likely to reverberate around the EU, and to dampen rather than enhance the prospects for new-build nuclear generation. Francois Hollande's election as President of France, on a platform of vowing to reduce French dependence on nuclear power from 75% to 50% by 2025, aligns with that view – as does his launch of a six-month national debate on the issue beginning in November 2012.

The case for gas presents a stark contrast to those for coal, oil, and nuclear power plant. Gas-fired CCGT offer an attractive combination of low setup costs, short lead times, low CO_2 emissions, modest physical and environmental footprint, good operational flexibility, high thermal efficiency, and a proven track record. For these reasons, this author suggests that, in the medium term, the majority of any shortfall in RES generation is likely to be filled using gas-fired CCGT. Such a development would obviously increase demand for gas, relative to the "EC Reference" or "IEA New Policies" scenarios. Figure 16 plots that additional requirement, as a function of the level of shortfall that pertains, assuming that the entire RES-E deficit is compensated using gas-fired CCGT with a thermal efficiency of 50%.

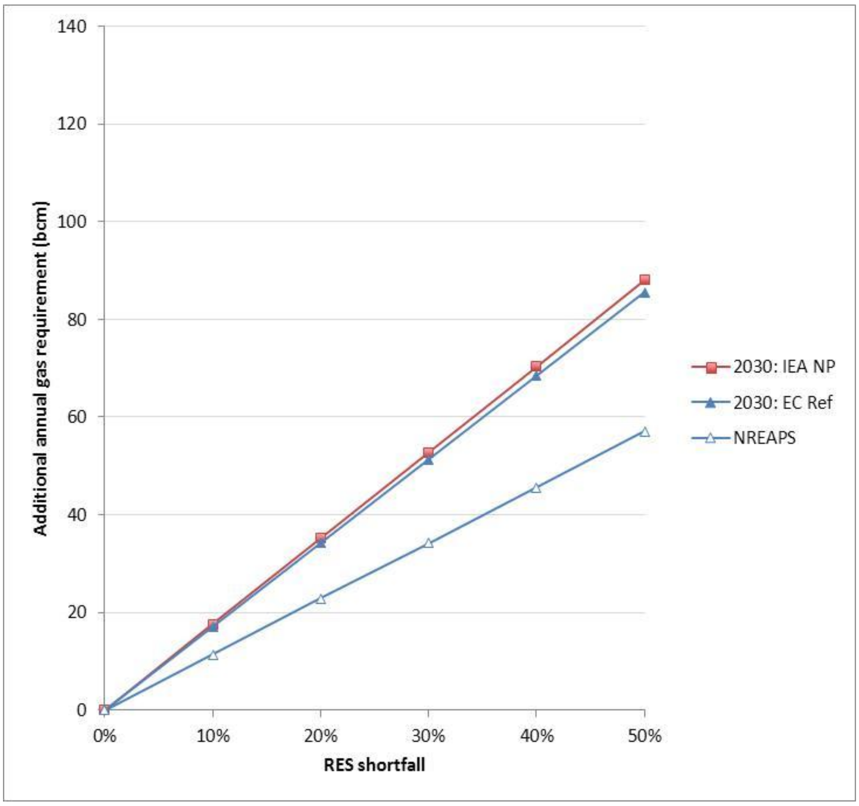


Figure 16 Impact of a shortfall in RES-E generation on EU27 gas demand, in the "RES shortfall" scenario.

The choice of an appropriate level of shortfall to consider is a personal one; this author settled on 20% as a level that is high, but plausible.

The "RES shortfall" scenario

The assumptions made in the "RES shortfall" scenario are as follows:

- Electricity derived from RES (RES-E) *increases by 20% less than projected*, after 2010 ;
- Heating and cooling powered by RES (RES-H/C) *increases by 20% less than projected*, after 2010;

- The "missing" RES-E is compensated entirely using gas-fired CCGT with efficiency of 50%;

- The "missing" RES-H/C is compensated entirely using an energy-equivalent quantity of natural gas.

In order to calculate the quantity of gas required in this scenario, the projected *growth* in RES-E or RES-H/C is first determined. For the period 2010-2020, data from the NREAPs is used (Beurskens and Hekkenburg, 2011); for 2020-2030 the projected growth rates specific to each scenario are employed. This projected growth is then reduced by 20%, and the quantity of natural gas required to replace the missing RES is found using assumptions 3 and 4 above. In practice of course, were such a shortfall to arise some of the deficit might be compensated using fuels other than natural gas – the assumptions here therefore represent a "maximum gas" demand response.

Table 5 indicates the quantities of electrical energy corresponding to a RES-E shortfall of 20% in 2020, and the additional gas that would be required to compensate the shortfall using gas-fired CCGT with an efficiency of 50%. It also indicates the energy-equivalent quantity of gas that would be required to replace a 20% shortfall in RES-H/C. The data for each of the "big five" economies is separated out.

	RES-E		RES_H/C	Total
	TWh	bcm	bcm	bcm
France	13.2	2.7	1.5	4.1
Germany	22.4	4.6	0.7	5.3
Italy	6.4	1.3	1.1	2.4
Spain	13.2	2.7	0.3	3.0
United Kingdom	17.1	3.5	1.0	4.4
Others	39.6	8.1	2.8	10.9
EU27	111.8	22.8	7.4	30.2

Table 5 Additional gas-fired electricity (TWh), and gas (bcm), required in 2020 to meet projected demand if there is a shortfall of 20% in RES-E and RES-H/C

The impact such an outcome would have on aggregate EU gas demand in 2020 and 2030, relative to the main EC and IEA scenarios, is indicated in Figure 17.

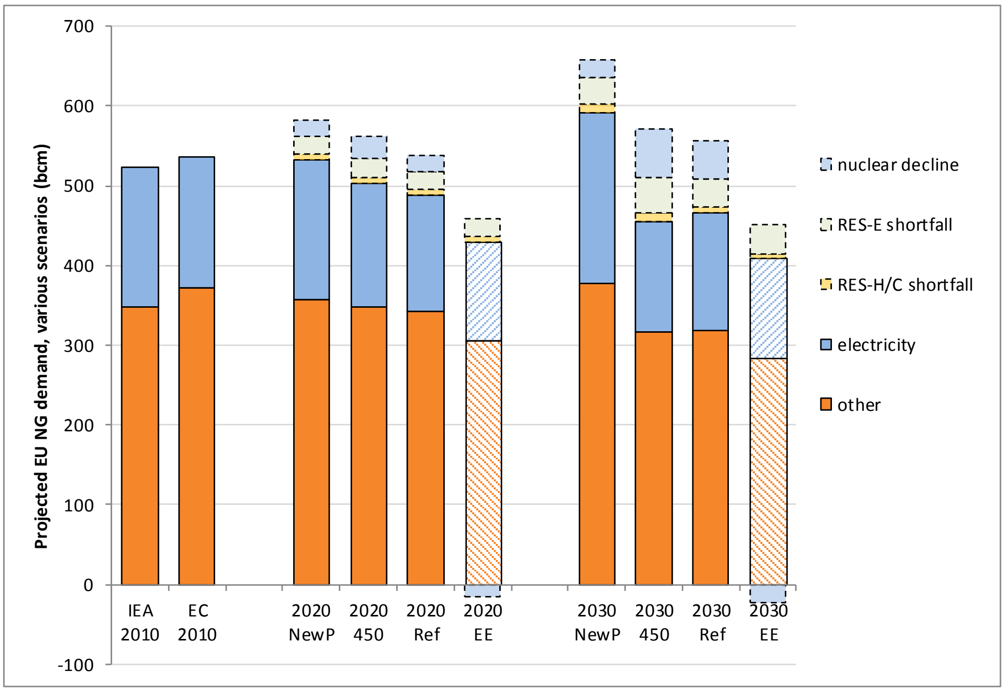


Figure 17 Projected EU27 demand for natural gas, for a range of scenarios, in the event of 20% shortfall in RES-E and RES-H/C

It is clear that, with the exception of the EC EE2020 scenario, the increased gas demand associated with such a significant shortfall in meeting the RES targets is roughly similar to that associated with the “nuclear decline” scenario. Figure 17 also illustrates that, if *both* the “RES shortfall” and “nuclear decline” scenarios came to pass – i.e. a plausible, worst-case scenario in terms of gas demand – then gas demand under the EC Reference scenario would remain at 2010 levels out to 2020, with a marginal increase of about 5% projected by 2030.

It is also noticeable that the two EC scenarios project significantly lower gas demand than the corresponding IEA scenarios in both 2020 and 2030, despite the fact that projections of overall energy demand is slightly higher in the EC scenarios. This reflects divergent assumptions concerning the future primary-energy mix with, as shown in Figure 12, the EC assuming the retention of significantly more coal in the electricity generation sector.

Impact of the proposed Energy Efficiency Directive (EED)

The “Energy Efficiency” (EE) scenario included in Figure 17 merits additional consideration. The scenario was prepared in preparation for the introduction of the new Energy Efficiency Directive (European Commission 2011a, 2011b), which was intended to ensure that the 20% efficiency target for 2020 is met. The initial proposal contained ambitious measures for promotion of energy efficiency, resulting in protracted negotiations with member states. Agreement on a moderated version of the proposal was reached between the Council of the European Union and the European Parliament in June 2012 (Council of the European Union, 2012), and formally adopted on 25 October 2012 (European Commission, 2012). The savings expected from the agreed measures are 17%, rather than the 20% initially sought. Therefore, the “EE” data in Figure 17 is presented in lightly-shaded format, to indicate that these data are aspirational rather than probable.

It is notable also that, were the 20% efficiency goal to be met, the reduction in output from nuclear generating plant would exceed that projected in the “nuclear decline” scenario. In that (improbable) case, a RES shortfall of up to 80% could be sustained before gas demand would exceed the 2010 level.

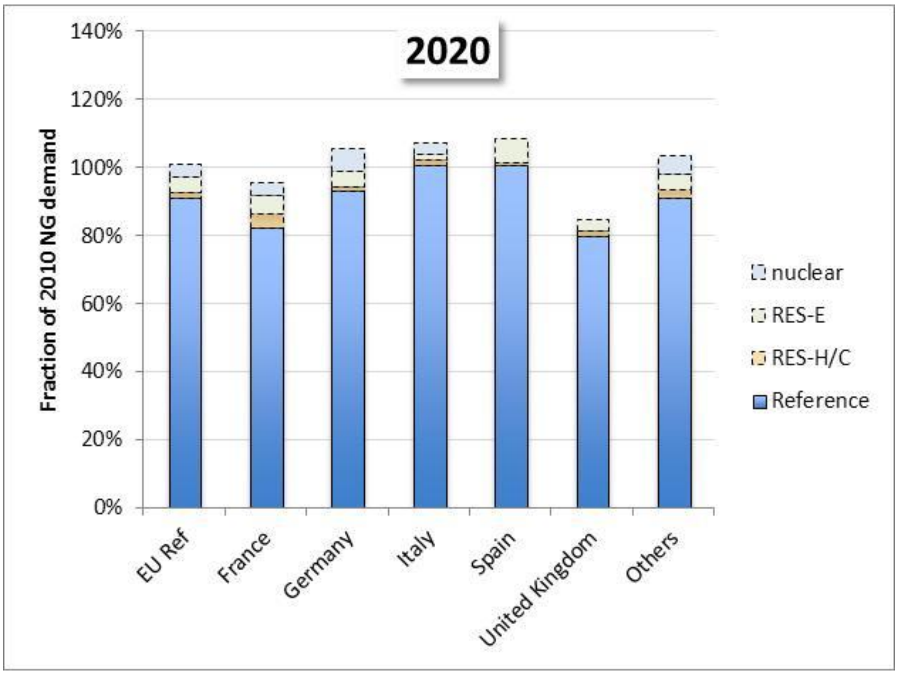
Regional factors and the 3rd Energy Package

Figure 18 shows (solid bars) the gas demand for the EU27, for each of the “big five”, and for “others”, as projected in the EC Reference scenario for 2020 and for 2030. The values are normalised by reference to 2010 demand, so that all can be conveniently shown on the same scale. Figure 18 also shows the regional impact of the “nuclear decline” and “RES shortfall” scenarios on gas demand (dashed outlines).

In 2020, the impact of these “high demand” scenarios is relatively modest. EU27 gas demand remains at 2010 levels, instead of declining by 10% as projected in the Reference scenario. Germany, Italy, and Spain see demand increase by 6%-9% above 2010 levels. For Germany, the “nuclear decline” scenario is more significant; for Spain, “RES shortfall” dominates.

By 2030, however, regional heterogeneity is more pronounced. Italy’s gas demand increases to 20% above 2010 levels, and Spain’s to 30% above. Italy’s increased demand is due almost entirely to its decision not to proceed with nuclear generation, and the consequent need to replace the missing generation with gas. In Spain the increase is split almost equally between substitution for planned retirement of nuclear plant, and substitution for a shortfall in RES. The impact of the "nuclear decline" on UK gas demand is quite substantial, but still not enough to bring demand above 85% of the 2010 level.

For Italy and Spain, the feasibility of meeting these demand increases is dependent on the strengthening of the relevant import channels (seaborne LNG, or pipelines) and gas and electricity grids – i.e. on the successful implementation of the EU Third Energy Package. However, it is highly likely that effective implementation of the Energy Efficiency Directive would mitigate these demand increases, and help to trim gas demand back towards 2010 levels.



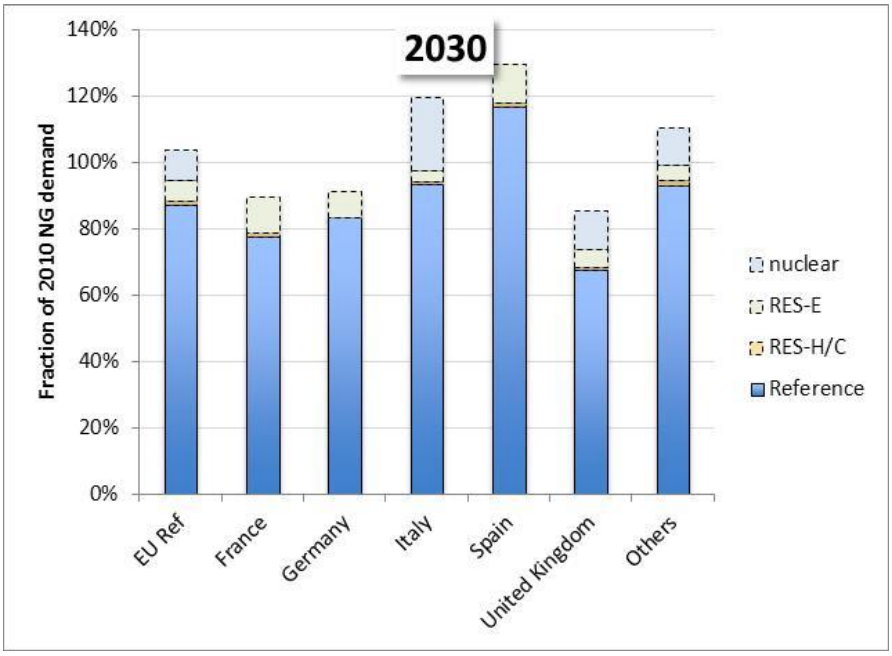


Figure 18 Additional gas required, by region, as a fraction of 2010 GIC, for the EC Reference scenario and as modified under the "20% RES shortfall" and "nuclear decline" scenarios

Conclusions

Twenty-four gas-demand projections for the EU27 have been analysed and compared. Divergences between projections are found to derive from to differing assumptions concerning the extent to which fossil fuels will be displaced by renewables and/or nuclear generation, and the extent to which gas will displace other fossil fuels as a fuel for electricity generation. Broadly speaking, the EC scenarios project that retention of coal-fired generation in 2020 and 2030 will be higher than in scenarios from other sources. This assumption, coupled with a higher level of confidence in the successful achievement of the 20-20-20 targets, means that the gas demand projections from the EC tend to be at the lower end of those reviewed. It is worth noting that recent history offers some support for the EC perspective: the post-Fukushima reduction in German nuclear generation has been compensated, primarily, by burning more coal; and the June 2012 agreement on the Energy Efficiency Directive provides a significant boost to efforts to meet all three of the EU 20-20-20 targets.

The paper also discusses two scenarios that were unforeseen when the projections were made. The “nuclear decline” scenario postulates an EU-wide decline in nuclear generation, as a consequence of the Fukushima disaster. The “RES shortfall” scenario hypothesises that, given the financial crisis currently engulfing the West, new RES additions will fall short of the installation targets outlined in each member state’s NREAP. At an EU level, the impact on gas demand of these new scenarios is found to be modest; regionally, however, Italy and Spain are found to have considerable exposure to the “nuclear decline” and the “RES shortfall” scenarios, respectively. Successful implementation of the EU Third Energy Plan and of the Energy Efficiency Directive, however, should provide significant reassurance in this respect.

Both the “nuclear decline” and “RES shortfall” scenarios assume that all related supply deficits are met using natural gas; although unlikely, this assumption sets an upper bound on the increase in gas demand that might be expected in practice if similar events were to arise. Moreover, simultaneous reductions in nuclear generation and in RES growth would severely undermine attempts to achieve all three of the EU 20-20-20 targets, and a sharp response might be expected from EU policy makers. Nonetheless, some reduction in nuclear new-build is now inevitable (relative to the EU Reference scenario), and some shortfall in meeting RES targets is at least plausible. Future gas demand might therefore be reasonably expected to lie above that projected in the EC Reference scenario, and below that projected if both the “nuclear decline” and “RES shortfall” scenarios came to pass. In absolute terms, this author expects EU27 gas demand to hover close to 500 bcm per annum out to 2020 at least, and possibly to 2030, with values below this level somewhat more likely than values above.

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