Fondazione Eni Enrico Mattei

NOTA DI LAVORO

86.2015

The Role of Natural Gas in the EU Decarbonisation Path

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Energy: Resources and Markets
Series Editor: Matteo Manera

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Summary

Over the last decade decarbonisation has become a key priority for the EU. However, on the contrary of renewable energy or energy efficiency, the role of gas in this process has never been clearly defined. This uncertainty opens a wide debate on the future role of gas in the EU energy system, particularly vis-à-vis the progressively stronger role of renewables in the EU energy mix. This paper tackles this issue with the aim to explore what role gas might play in making the EU decarbonisation path more balanced and secure up to 2030 and beyond.

Keywords*:* Gas, Decarbonisation, EU Energy Policy
JEL classification: Q40, Q42, Q48

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The EU's Quest for Decarbonisation: From Kyoto to the 20-20-20 Targets

Over the last decade the decarbonisation of the energy system has progressively become a key priority for the European Union (EU)[1].

The first steps in this direction were taken by the EU in the framework of the international negotiations on climate change. In 2002 the EU (then still called the European Community) adopted a legislation approving the Kyoto Protocol, stating that it would jointly fulfill with its Member States[2] the commitment to reduce the collective greenhouse gas (GHG) emissions in the 2008-2012 period to 8% below 1990 levels[3].

In this new international context, EU Member States agreed for the first time on the need for a comprehensive common action towards the increasingly challenging energy issues at the Hampton Court informal EU summit held in October 2005[4].

Following the political momentum emerged at the summit, the European Commission published in early 2006 a Green Paper on developing a common and coherent European energy policy entitled "A European Strategy for Sustainable, Competitive and Secure Energy"[5]. As the title suggests, the paper delineated a European energy policy structured on three key pillars, which continue to remain fundamental also today.

The Green Paper received the praise of the European Council of March 2006, which called for «an Energy Policy for Europe, aiming at effective Community policy, coherence between Member States and consistency between actions in different policy areas and fulfilling in a balanced way the three objectives of security of supply, competitiveness and environmental sustainability.»[6] The European Council therefore invited the European Commission to prepare further actions.

The Commission reacted to this endorsement by issuing in January 2007 the so-called "Energy and Climate Package", a set of measures centred on the

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[1] For a wider discussion of the evolution of the EU energy and climate policy please refer to: Simone Tagliapietra (2014), *Towards a EU Energy Union: The Need to Focus on Security of Energy Supply*, Nota di Lavoro n. 95.2014, Fondazione Eni Enrico Mattei, Milan.

[2] 15 at the time: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.

[3] European Council (2002), *Decision Concerning the Approval, on Behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the Joint Fulfilment of Commitments Thereunder*, 2002/358/EC, 25 April.

[4] During the summit the EU heads of State or Government discussed a plan presented by the British Prime Minister to create a true European energy policy and agreed on the need of advancing the EU action in this field. See: i) Tony Blair (2005), *Press Conference at EU Informal Summit Hampton Court,* 27 October; ii) Dieter Helm (2005), *European Energy Policy: Securing Supplies and Meeting the Challenge of Climate Change*, Paper prepared for the UK Presidency of the EU; iii) EurActiv (2005), *Blair Calls for Stronger EU Energy Policy Co-operation*, 31 October.

[5] European Commission (2006), *A European Strategy for Sustainable, Competitive and Secure Energy*, Green Paper of the Commission, COM(2006) 105 final.

[6] European Council (2006), *Presidency Conclusions*, No 7775/1/06 REV1, 24 March.

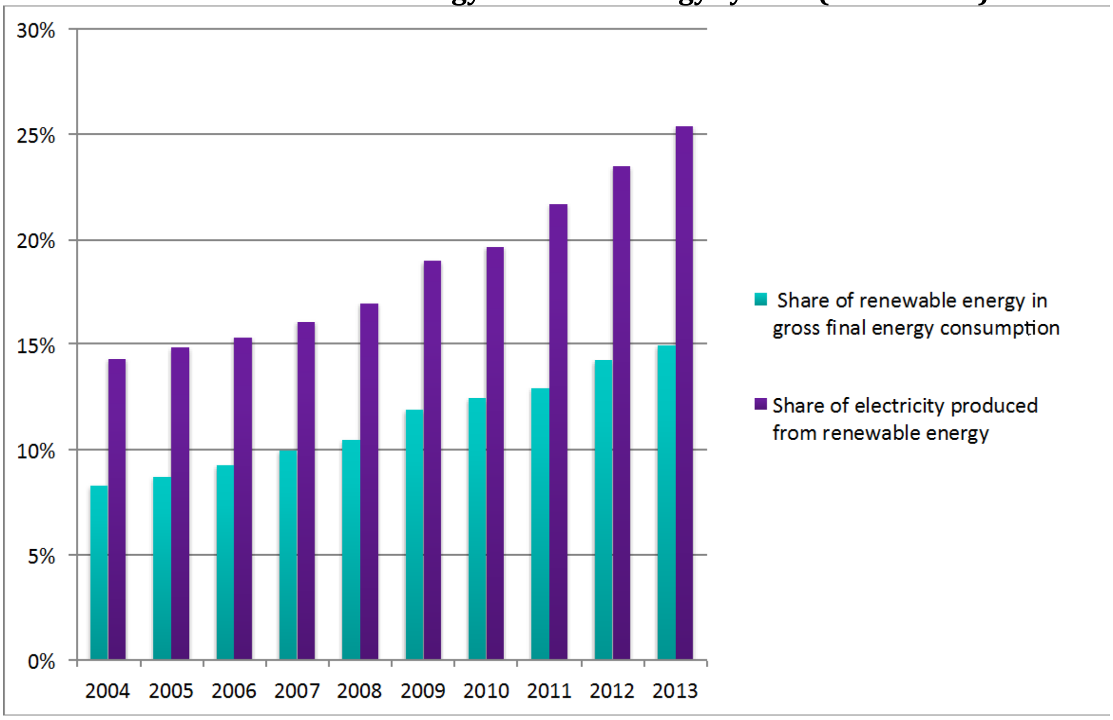
Communication "An Energy Policy for Europe"[7] aimed at establishing a new European energy policy in line with the one proposed in the Green Paper (and thus focused on combat climate change, increase the EU' energy competitiveness and boost the EU's energy security of supply).

The European Council of March 2007 endorsed the package[8], which was then finally adopted by the European Parliament in December 2008 after months of tough negotiations between Member States.

In addition to the definition of the triple paradigm sustainability-competitiveness-security characterizing the European energy policy, an important advancement included in the "Energy and Climate Package" was represented by the EU's commitment to reach specific targets related to GHG emissions reduction, renewable energies and energy efficiency: the well-known 20-20-20 targets. These targets encompassed a 20% reduction of GHG emissions compared to 1990, a 20% decrease of final energy demand compared to a baseline scenario and the obtainment of a level of 20% of renewable energy in total energy consumption, by 2020.

These targets had a substantial impact on the EU energy system, particularly as far as the penetration of renewable energy in the system is concerned. As Fig. 1 illustrates, the share of renewable energy in the EU energy system grew substantially over the last decade, reaching a share of 15% of EU gross final energy consumption and a share of 25% of EU electricity production.

Figure 1
Share of renewable energy in the EU energy system (2004-2013)



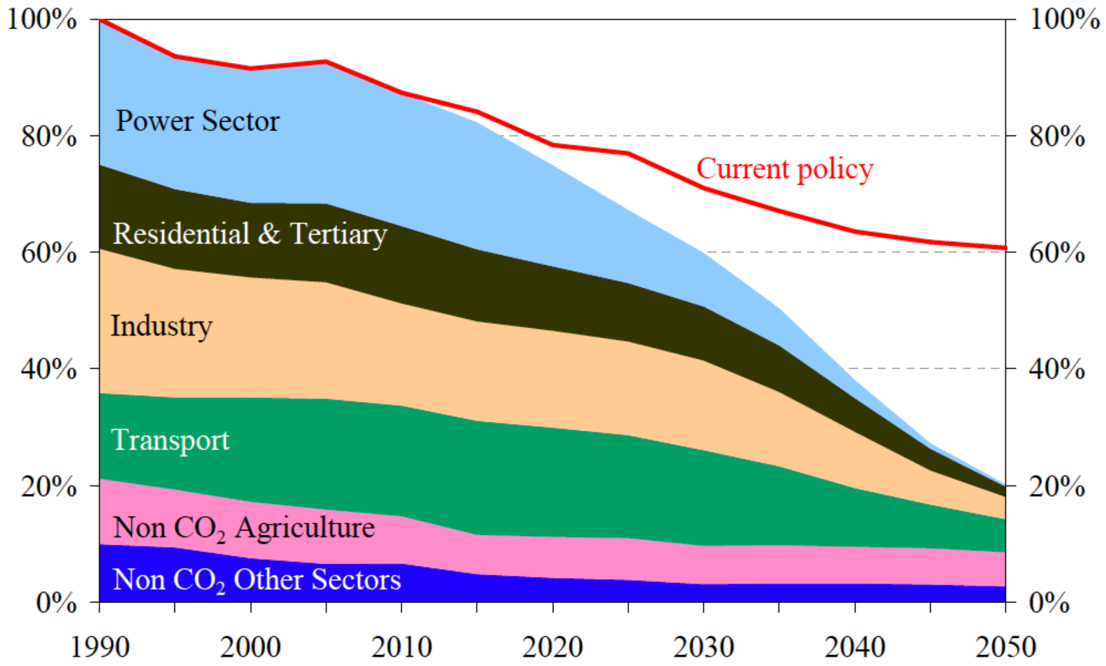
Source: own elaboration on Eurostat (2015)[9].

[7] European Commission (2007), *An Energy Policy for Europe*, Communication from the Commission to the European Council and the European Parliament, COM(2007) 1 final.
[8] European Council (2007), *Presidency Conclusions*, No 7224/07, 9 March.

After the 20-20-20 Targets: The 2050 Roadmaps and the 2030 Framework

In 2011 the European Commission adopted the Communication "A Roadmap for Moving to a Competitive Low Carbon Economy in 2050"[10] with the aim to outline its new long-term decarbonisation targets. The document strengthened the previous targets, to the level of envisaging a domestic GHG emissions' cut of 80% by 2050 compared to 1990 (Fig. 2). Furthermore, the document reiterated the concept that the decarbonisation of the energy system is possible and could even be less costly in the long run than business-as-usual policies.

Figure 2
EU GHG emissions towards an 80% domestic reduction (100% =1990)



Source: European Commission (2011a), p. 5.

In order to explore the challenges posed by delivering this decarbonisation objective while at the same time ensuring security of energy supply and competitiveness, the Commission adopted in the same year the Communication "Energy Roadmap 2050"[11]. As far as natural gas is concerned, the Roadmap underlined that the fuel will be critical for the transformation of the EU energy system. According to the decarbonisation scenarios underpinning the document, natural gas will perform better than other fossil fuels and will basically maintain its 2005 share in the EU primary energy consumption up to 2050 (Fig. 3).

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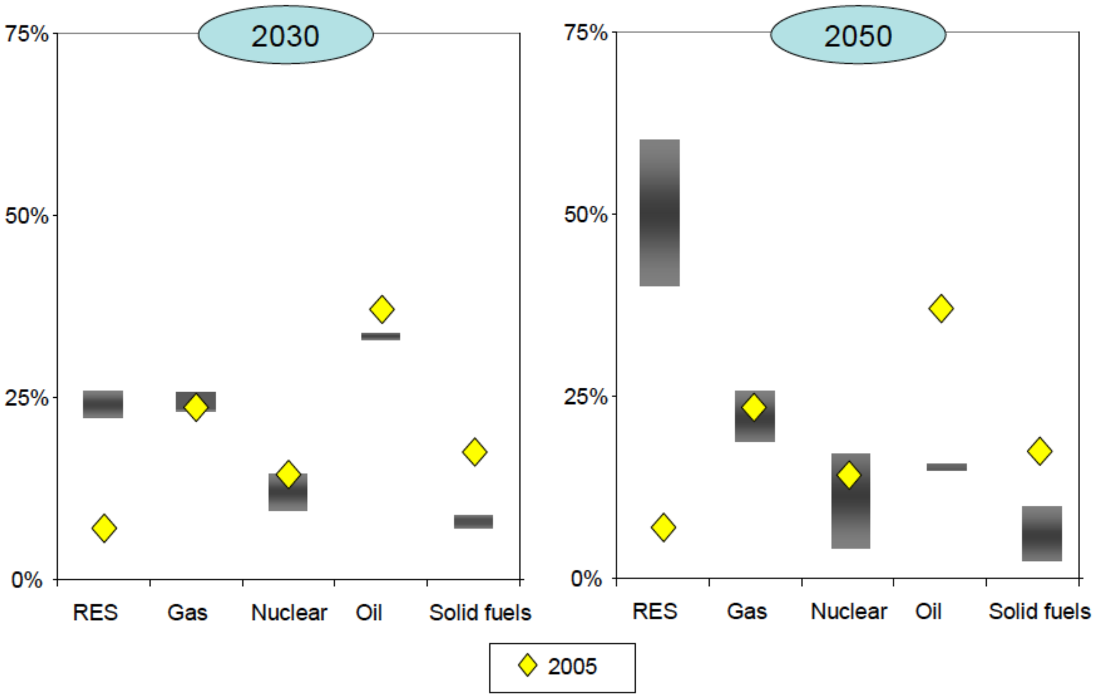
[9] Eurostat (2015), *SHARES 2013 - SHort Assessment of Renewable Energy Sources*, available at: http://ec.europa.eu/eurostat/web/energy/data/shares

[10] European Commission (2011a), *A Roadmap for Moving to a Competitive Low Carbon Economy in 2050*, Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee on the Regions, COM(2011) 112 final.

[11] European Commission (2011b) *Energy Roadmap 2050*, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee on the Regions, COM(2011) 885 final.

Figure 3
EU decarbonisation scenarios – 2030 and 2050 range of fuel shares in primary energy consumption compared with 2005 outcome (in %)



Source: European Commission (2011b), p. 5.

In line with the two 2050 roadmaps, the European Commission further detailed its long-term decarbonisation strategy in 2014, with the adoption of the Communication "A Policy Framework for Climate and Energy in the Period from 2020 to 2030"[12]. This new document focuses on the reduction of GHG emissions (by 40% below the 1990 levels by 2030), on the increase of renewable energy use (at least 27% of the EU's energy consumption by 2030), on the increase of energy efficiency (27% energy savings target for 2030) and on the reform of the EU Emissions Trading System (ETS).

This set of provisions was endorsed by the European Council of October 2014[13]. Following this approval, the Commission made its initial legislative proposals to implement the 2030 climate and energy framework at the end of February 2015. The proposals, set out in the "Energy Union Package"[14], aim to provide a

[12] European Commission (2014), *A Policy Framework for Climate and Energy in the Period from 2020 to 2030*, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee on the Regions, COM(2014) 15, final.
[13] European Council (2014), *Conclusions on 2030 Climate and Energy Policy Framework*, SN 79/14, 24 October.
[14] The package is composed by three Communications: i) European Commission (2015a), *A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy*, COM(2015) 80 final; European Commission (2015b), *The Paris Protocol – A blueprint for tackling global climate change beyond 2020*, COM(2015) 81 final; European Commission (2015c),

coherent approach to climate change, energy security and competitiveness, also to achieve the goals agreed under the 2030 framework.

It is important to underline that, unlike in the previous 2020 framework, the new EU targets will not be translated into national targets via EU legislation. Officially, this is due to the willingness of leaving «greater flexibility for Member States to meet their GHG reduction targets in the most cost-effective manner in accordance with their specific circumstances, energy mixes and capacities to produce renewable energy.»[15] In reality, this seems to be mainly due to the lack of a common vision among Member States on the future trajectory of the decarbonisation path, with certain countries (from the United Kingdom to Poland) being reluctant to afford its high costs and being more sensitive to the competitiveness and security pillars of EU energy policy. This situation clearly raises questions on how the new 2030 framework will concretely be implemented.

In this uncertain situation, the role of natural gas in the EU decarbonisation path basically remains undefined, like the one of all the other components of the energy system with the notably exception of renewable energy and energy efficiency. This uncertainty opens a wide debate on the future role of natural gas in the EU energy system, particularly *vis-à-vis* the progressively stronger role of renewable energy in the EU energy mix.

Considering that following the decarbonisation path renewable energy will further consolidate its position of key independent variable in the EU energy equation, the next section will provide a critical assessment of the challenges and opportunities related to a major scale-up of variable renewable energy sources in the EU energy system by 2030.

Towards the achievement of the 2030 renewables target: the way ahead

According to the European Commission the increase of renewable energy use to 27% of overall EU energy consumption by 2030 will imply that in the same year about 45% of electricity in the EU will have to be generated by renewable energy sources[16].

This clearly represents a substantial expansion of the current contribution level of renewable energy to the EU electricity generation, estimated by Eurostat at about 25%[17].

As illustrated in Fig. 4, the EU renewable electricity generation mix still continues to be largely composed by hydro. Considering that the hydro potential in the EU is already well exploited, the new 2030 target will thus require an

Achieving the 10% electricity interconnection target - Making Europe's electricity grid fit for 2020, COM(2015) 82 final.

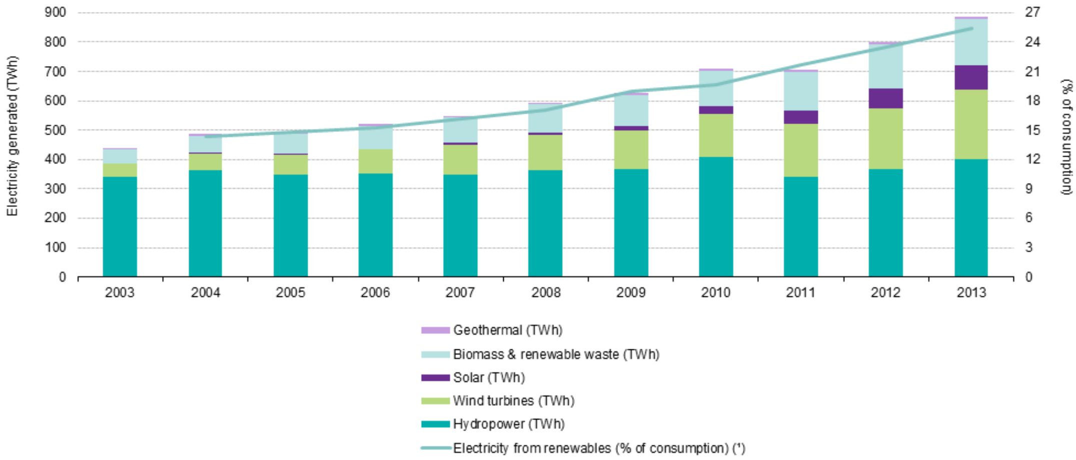
[15] European Commission (2014), *Op. Cit.*, p. 6. This attitude reflects the traditional reluctance of Member States to give up to the EU any competence concerning the composition of their own energy mixes. It also underpins the provisions on energy of the Treaty of Lisbon, contained in Article 194 TFUE. See: Official Journal of the European Union (2008), *Consolidated versions of the Treaty on European Union (TEU) and the Treaty on the Functioning of the European Union (TFEU)*, OJ 2008/C 115.

[16] European Commission (2014), *Op. Cit.*, p. 6.

[17] Eurostat (2015), *Op. Cit.*, data refers to 2013.

extensive development of variable renewable energy sources such as wind energy and solar energy (namely photovoltaic -PV-).

Figure 4
Electricity generated by renewable energy sources in the EU (2003-2013)



Source: Eurostat (2015).

As outlined in a recent study by EDF, up to date wind and PV have been developed with a "fit and forget" logic, being not integrated into the electricity market and having priority dispatch and access to network[18]. However, a massive integration of such variable renewable energy sources into the system will require profound changes in terms of power system operation, market design, infrastructure development and transformation of conventional generation mix.

Being dependent on uncertain weather conditions, wind and PV are variable by definition and their output is both intermittent and non-dispatchable. For this reason more flexibility will be required in the system, in order to reduce this intermittency and ensure the overall stability of the system. Flexible resources include dispatchable back-up power plants, demand-side management and response, energy storage facilities and interconnections with adjacent markets.

The main tool to reduce the intermittency of wind and PV electricity generation is to aggregate their outputs over a wider geographical area. In fact, as exemplified by Fig. 5, intermittency at site level is progressively smoothed at regional, national and continental levels as a result of the diversity of outputs.

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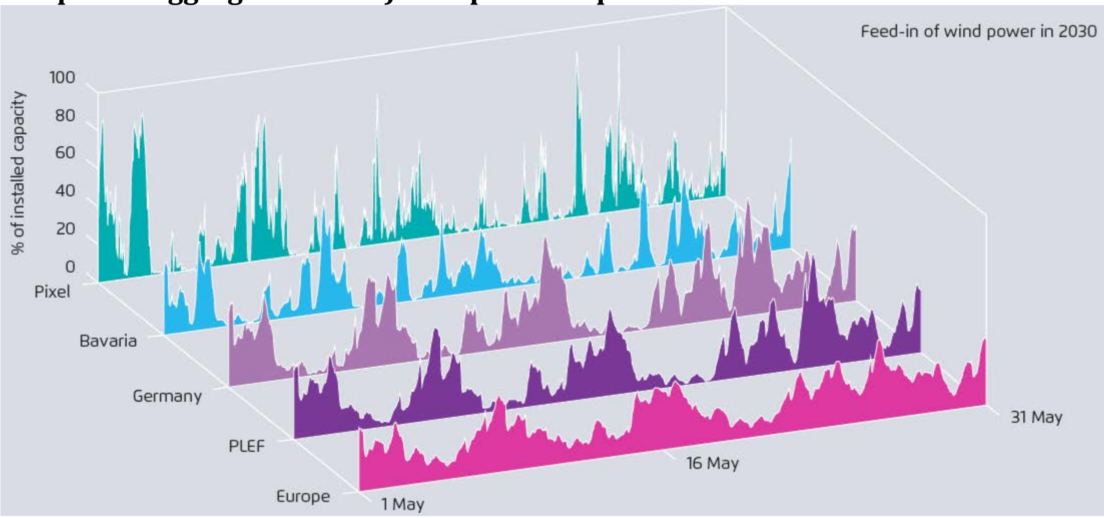
[18] EDF (2015), *Technical and Economic Analysis of the European Electricity System with 60% RES*, Research and Development Division, 17 June 2015.

Figure 5

Time series of onshore wind power generation in a simulation for May 2030 at different levels of aggregation (as a percentage of the installed capacity at the specific aggregation level). One pixel is equivalent to an area of 2.8 x 2.8 km.

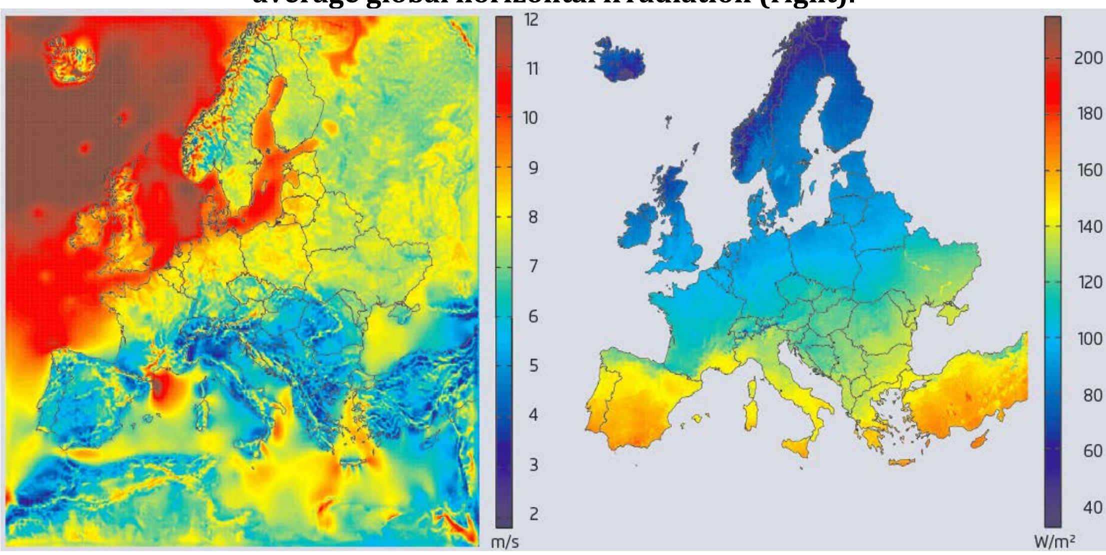


Source: Fraunhofer IWES (2015)[19], p. 7.

In other words, the integration of EU electricity systems can mitigate flexibility needs arising from wind and PV, due to different weather patterns across Europe (Fig. 6) that decorrelate single electricity generation peaks, yielding geographical smoothing effects that ultimately transform intermittency at local level in variability at EU level.

Figure 6

Wind and solar resource throughout Europe for the year 2007. Average wind speed approx. 70 m above the ground (left) and average global horizontal irradiation (right).



Source: Fraunhofer IWES (2015), p. 21.

[19] Fraunhofer IWES (2015), *The European Power System in 2030: Flexibility Challenges and Integration Benefits. An Analysis with a Focus on the Pentalateral Energy Forum Region*, Analysis on behalf of Agora Energiewende.

In addition to this, a strong integration of EU electricity systems can allow the cross-border exchanges necessary to minimise surplus renewable electricity generation. As outlined by Fraunhofer IWES, «when no trading options exist, hours with high domestic wind and PV generation require that generation from renewables be stored or curtailed in part. With market integration, decorrelated production peaks across countries enable exports to regions where the load is not covered. By contrast, a hypothetical national autarchy case has storage or curtailment requirements that are ten times as high.»[20]

The process of integration of EU electricity systems will require the development of an appropriate network infrastructure, and particularly of interconnections not only able to transport wind and PV electricity production to consuming centres but also to share thermal generation capacity between EU countries.

The development of an appropriate infrastructure is thus not only crucial to reduce variability of wind and PV at system level but also to reduce the overall need for back-up electricity generation. This represents a vital element, particularly if considering that by displacing baseload generation (i.e. from conventional sources) wind and PV do increase the need for back-up capacity[21].

With an increased role of wind and PV in EU electricity systems, conventional plants are thus progressively switching from their traditional roles to a new back-up role, essential to guarantee the stability of the overall system *vis-à-vis* the variability of wind and PV.

In addition to interconnections, flexibility in the system could theoretically be enhanced with demand side management and demand response mechanisms as well as energy storage. However, these solutions face major challenges. Demand mechanisms are partially challenged by socio-economic issues such as consumer behavioural changes, albeit can well be implemented in the industry and services sectors first. Energy storage is challenged by a persistent technological gap; in fact, to date the only operative option is represented by pumped storage hydropower, as other technologies such as battery systems, compressed air energy storage, flywheels and hydrogen storage continue to be highly expensive. In sum, in the medium-term these solutions will unlikely provide a substantial contribution for back-up in the system.

In this framework, exploiting the complementary roles of renewable and conventional electricity generation sources will be even more important in the future EU electricity systems. In particular, conventional sources will continue to play a key role in guaranteeing system stability and security of supply by being able to provide larger and more rapid increases and decreases in output in order to accommodate increasing amounts of variable renewables-based generation.

With regard to this specific aspect, the International Energy Agency (IEA) points out that «the integration of high levels of wind and PV into electricity systems may require market framework reforms to guarantee a sufficient level of investment in the conventional power plants needed to keep the system in

[20] *Ibidem*, p. 1.

[21] In fact, generation from wind and PV contributes to the supply of energy but their stochastic nature means that their outputs do not always coincide with periods of high demand and consequently they make a minor contribution to capacity.

balance, together with other measures to shift demand when sun is not shining or the wind is not blowing. Failing to address these needs in advance will negatively impact the reliability of the electricity system.»[22]

On the basis of the situation illustrated in this section, this seems to be particularly urgent in the case of the EU, where variable renewables are set to become the cornerstone of the electricity system, increasing the variability that the rest of the system has to manage. Of course, a new EU electricity market design should also be able to provide adequate economic incentive for investments in the previously mentioned flexibility options (i.e. network infrastructure expansion, development of smart grids, adoption of demand side measures and development of energy storage technologies), crucial to ensure the sustainability of the EU decarbonisation path also beyond the 2030 horizon.

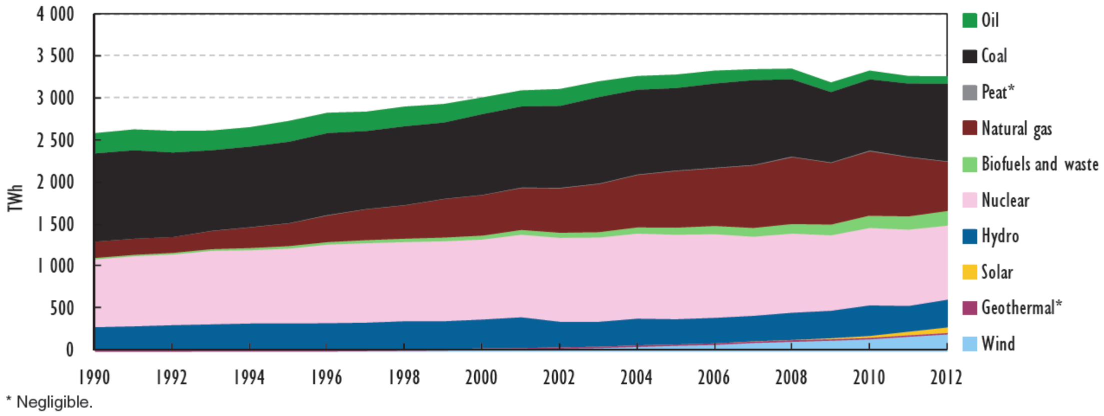
To make a long story short, in order to achieve its 2030 renewable energy target the EU will need to rethink its electricity system beyond renewable energy itself. The role of conventional fuels in the future system should be better investigated, also to provide investors with the minimum grade of certainty needed to make today investments that will define the EU electricity system of 2030 and beyond. This is particularly true considering the recent, controversial, evolution of the EU electricity generation mix, which will be described in the next section.

The EU decarbonisation path and the (unwelcome) renaissance of coal

As the previous sections illustrated, over the last decade the EU has successfully promoted the expansion of renewable energy sources in the European electricity generation mix.

However, part of the environmental benefits generated by this complex and costly expansion has been nullified by the parallel growth of coal in the mix, a trend particularly emerged after 2010 (Fig. 7).

Figure 7
Electricity generation in the EU by source (1990-2012)



Source: IEA (2014)[23], p. 102.

[22] IEA (2015), *Energy and Climate Change*, World Energy Outlook Special Report, Paris, p. 112.
[23] IEA (2014), *European Union 2014 Review,* Energy Policies of IEA Countries, Paris.

The key driver underpinning this trend was the US shale gas revolution. In fact, as US utilities progressively shifted into natural gas, American coal miners had to look for new markets abroad.

In the meantime, many new large mining capacities that were committed in Indonesia and Australia during the boom period of Asian demand (2008-2011) progressively came online between 2012 and 2014, adding even more low-cost supply to the international coal market. Considering that in the meantime coal demand growth in Asia resulted to be lower than expected, the global coal market entered a situation of over-supply.

As a result of this trend, overall EU coal imports increased from 104 million tons of oil equivalent (Mtoe) in 2010 to 119 Mtoe in 2014 and coal import prices plunged from EUR 130 per tonne (t) in March 2008 to below EUR 60 per t in May 2014 at the EU import reference price[24]. Due to a progressive transition from oil indexation to spot pricing, natural gas prices in the EU also decreased over the last years, but at a far slower pace than coal. In this framework, coal became more competitive against natural gas in the EU electricity generation sector. This led to a significant gas-to-coal switch in the EU, mainly in the United Kingdom, Spain and Germany, but also in the Netherlands.

Considering that coal-fired electricity generation emits more CO_2 per kWh than other power plants, this situation represents a substantial challenge to the EU decarbonisation path. This is particularly true if considering that the efficiency of the EU's coal-fired power plants fleet is on average low, with a level of 36% compared to the one of 45% characterizing the most efficient plants, such as the ultra-super critical power plants in Germany[25].

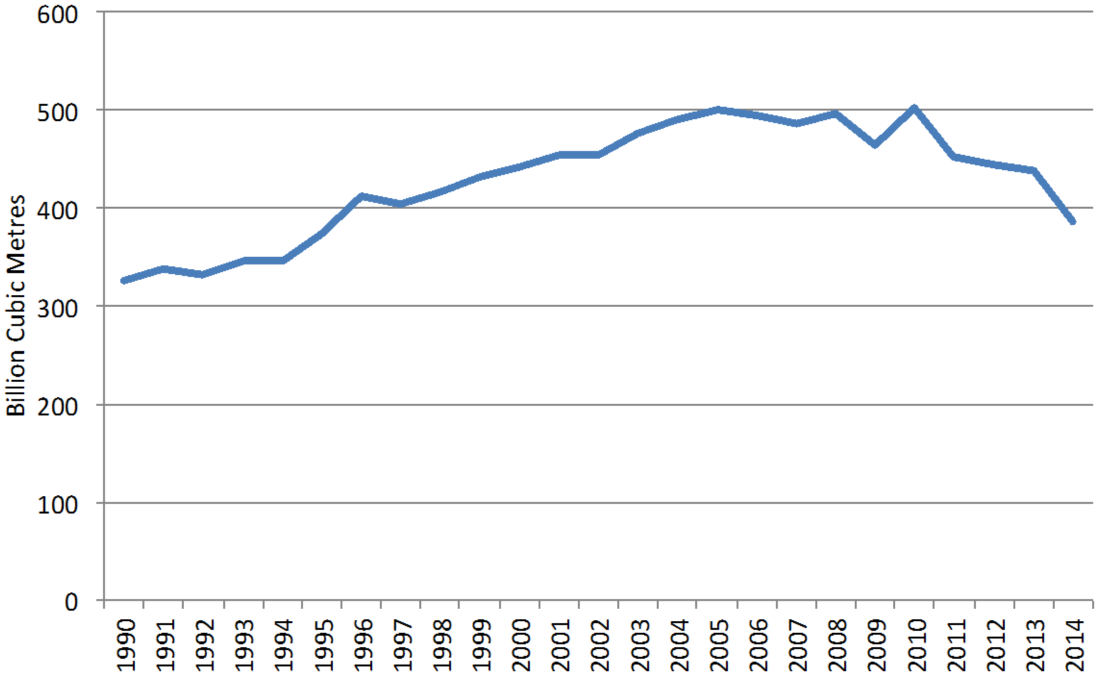
The existing EU environmental regulation has not had a relevant impact on the cost-advantage that coal-fired generators have enjoyed over their competitors. In fact, according to the IEA, the EU Large Combustion Plant Directive (LCPD)[26] «is expected to lead to retiring 8 GW of coal-fired power capacity in the United Kingdom. In other EU countries, reductions are expected to be much lower, totaling around 10 GW. All in all, the shutdowns would affect around 2% of EU total generating capacity.»[27]

[24] IEA (2014), *Op. Cit.*, p. 226.
[25] IEA (2014), *Op. Cit.*, p. 224.
[26] Official Journal (2001), *Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the Limitation of Emissions of Certain Pollutants Into the Air From Large Combustion Plants*, L 309, Vol. 44, 27 November 2011. The Directive aims at reducing acidification, ground level ozone and particulates by controlling the emissions of sulphur dioxide, oxides of nitrogen and dust from large combustion plants. All combustion plants built after 1987 must comply with the LCPD emission limits. Those power stations in operation before 1987 have three options for complying: 1) by installing emission abatement equipment, e.g. flue-gas desulphurisation; 2) by operating within a "National Plan" setting a national annual mass of emissions calculated by applying the emission limit value (ELV) approach to existing plants, on the basis of those plants' average actual operating hours, fuel used and thermal input, over the five years to 2000; or 3) by opting out of the directive. An existing plant that chooses to opt out is restricted to 20,000 total hours of operation after 2007 and must close by the end of 2015.
[27] IEA (2014), *Op. Cit.*, p. 224.

In short, a global market over-supply combined with a lack of proper environmental regulation at the EU level, allowed coal to stage a renaissance in EU electricity market over the last few years.

In this context, natural gas found itself in the uncomfortable position to be squeezed by subsidised renewable energy sources on one side and cheap coal on the other side. This added additional pressure to the already weak natural gas demand conditions in the EU (due to the economic crisis and mild winters), resulting in a dramatic plunge of EU natural gas demand from a peak level of 505 billion cubic metres (bcm) in 2010 to a level of 394 bcm in 2014: the same level recorded in 1995[28] (Fig. 8).

Figure 8
EU natural gas demand (1990-2014)



Source: own elaboration on BP (2015).

At a first view, this graph might suggest that the role of natural gas in the EU energy system is irreversibly in decline, particularly if taking into consideration the EU's quest to further advance renewable energy in electricity generation. However, considering that the previous analysis clearly illustrated that a strong expansion of renewable energy by 2030 and beyond will not exclude a key role of conventional electricity generation in the system, the future role of natural gas in the EU decarbonisation path does deserve to be better explored.

Exploring the future role of natural gas in the EU decarbonisation path

Albeit technically feasible, a further large-scale development of wind and PV in the EU electricity system might potentially encounter economic barriers due to increasing system integration costs. This issue is particularly relevant if

[28] BP (2015), *BP Statistical Review of World Energy 2015*, London.

considering that the EU itself acknowledges «that in the future, the benefits of renewable energy must be exploited in a way which is to the greatest extent possible market driven»[29] and thus not based on support schemes that ultimately hinder market integration and reduce cost-efficiency.

In this context, assessing the future role of conventional electricity generation is of vital importance for the stability and security of the EU electricity system. As an overall trend, considering the previously illustrated characteristics of an electricity system centred on variable renewable energy sources, what will be needed is primarily a park of flexible power plants, where flexibility of a power plant is defined as its ability to run in partial load as well as by parameters such as ramping rates, start-up time and minimum down time[30].

Among the various possible options of conventional electricity generation (natural gas, coal, nuclear and oil), natural gas seems to be the fuel better placed to play a key complementary role to wind and PV in the decarbonisation path for the following four reasons:

1) First of all, natural gas-fired power plants can provide the flexible back-up capacity needed in a system with high share of variable renewable energy sources. An analysis carried out by Eurelectric (see Fig. 9) shows that among conventional electricity generation technologies pumped storage is the most responsive one, as it can be called upon to generate electricity almost instantaneously and as it can ramp up and down by more than 40% of the nominal output per minute. However, being contingent to specific geographical conditions, pumped storage cannot provide the flexible back-up capacity needed at system level. Among other technologies, combined-cycle gas turbines (CCGTs) are particularly suitable for load-following operation as they have both fast load gradients (4%/min) and can be brought online fairly quickly (less then 1.5 hours from warm conditions). These performances are far beyond those of coal-fired power plants (which are less responsive than any other technologies) and of nuclear power plants (which cannot be brought online from cold and warm conditions in timeframes similar to those of other technologies). For this reason natural gas-fired power plants can well play an important role in meeting the flexibility challenge arising from variable renewable energy sources[31].

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[29] European Commission (2014), *Op. Cit.*, p. 6.

[30] In all thermal power plants partial load operation is restricted by a minimum power generation.

[31] For the complete analysis please refer to: Eurelectric (2011), *Flexible Generation: Backing-Up Renewables*, Brussels.

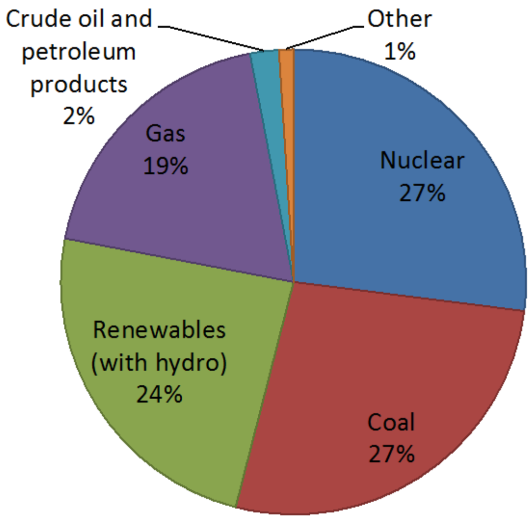
Figure 9
Flexibility of conventional electricity generation technologies
Note: NPP: nuclear power plants; HC: hard-coal fired power plants; Lign: lignite-fired power plants; CCG: combined cycle gas-fired power plants; PS: pumped storage power plants.

	NPP	HC	LIGN	CCG	PS
Start-up Time "cold"	~ 40H	~ 6H	~ 10H	< 2H	~ 0,1H
Start-up Time "warm"	~ 40H	~ 3H	~ 6H	< 1,5H	~ 0,1H
Load Gradient ↗ "nominal Output"	~ 5%/M	~ 2%/M	~ 2%/M	~ 4%/M	> 40%/M
Load Gradient ↘ "nominal Output"	~ 5%/M	~ 2%/M	~ 2%/M	~ 4%/M	> 40%/M
Minimal Shutdown Time			← NO →		~ 10H
Minimal possible Load	50%	40%	40%	<50%	~ 15%

Source: Eurelectric (2011), p. 19.

2) By displacing coal in the EU electricity generation systems natural gas has the potential to generate immediate and substantial GHG emissions' reductions. In fact, modern CCGTs produce about half the CO_2 emissions per unit of electricity generated compared with coal-fired plants[32]. Considering that coal still plays a key role in the EU electricity system (see Fig. 10) the scale of this switch might provide a consistent contribution to the EU 2030 GHG emissions reduction target.

Figure 10
EU electricity generation by source, 2012



Source: own elaboration on Eurostat (2015).

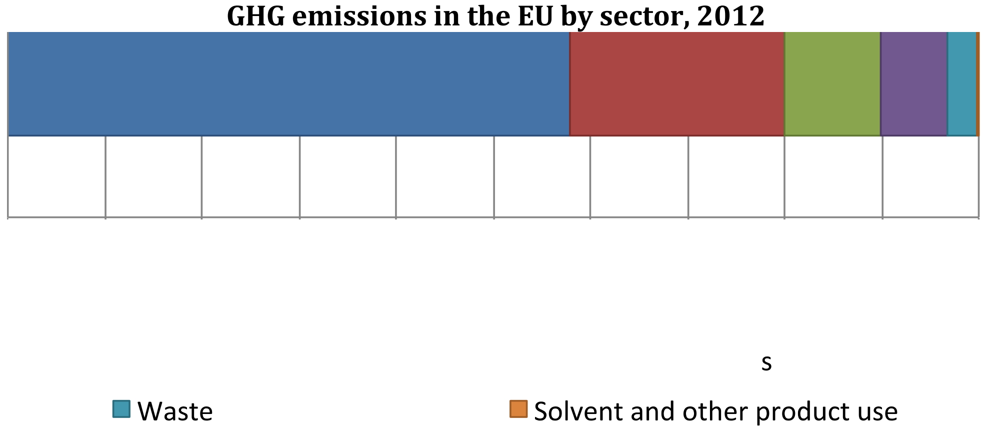
3) A switch from coal-fired power plants to natural gas-fired power plants will not only positively impact the EU environmental effort at macro level (i.e. climate change mitigation) but also at micro level. In fact, as the IEA outlines, «compared with coal and oil, natural gas avoids or reduces much of the local environmental damage arising from fossil-fuel use. Gas gives off fewer pollutants when burned, including the nitrogen oxide (NO_x) that contributes to acidification and ground-

[32] IEA (2011), *Are We Entering a Golden Age of Gas?*, World Energy Outlook Special Report, Paris, p. 85

level ozone formation; the sulphur dioxide (SO_2) that (with NO_x) causes acid rain; and the particulate matter that (again with NO_x) causes smog and poor air quality. Consequently, using natural gas instead of other fossil fuels in electricity generation (and other sectors) offers the opportunity to improve air quality, especially in and around cities, where this problem is most acute.»[33]

4) Being the second-largest emitter of CO_2 after the electricity generation sector (Fig. 11), the transport sector has an important role to play in the EU decarbonisation path.

Figure 11
GHG emissions in the EU by sector, 2012



Source: own elaboration on Eurostat (2015).

GHG emissions from the transport sector decreased since 2007 due to high oil prices, increased efficiency of passengers' cars and slower growth in mobility. The European Commission[34] expects this trend to continue but this will still not be sufficient to meet the goal to reduce GHG emissions from the sector by 60% by 2050 compared to 1990 and by 20% by 2030 compared to emissions in 2008 as set by the Transport White Paper[35] adopted in 2011.

Notwithstanding their current difficulties (e.g. relatively high costs, low energy density of batteries and lack of recharging infrastructure), electric vehicles will most likely play a key role in the future decarbonisation of the transport sector. However, natural gas can also play a role in the field, not only in terms of compressed natural gas (CNG) vehicles, but particularly in terms of liquefied natural gas (LNG) for trucks and for ships.

For instance, ExxonMobil does not expect a significant growth in natural gas as a transportation fuel for light-duty vehicles (as CNG vehicles cost more than comparable gasoline-powered cars, have a shorter driving range due to CNG's lower energy intensity, and challenging remains the development of a large network of easily accessible refueling stations) but it does expect a significant development in terms of LNG for trucks, as LNG-fuelled long-haul trucks have the capacity to travel up to 1,200 km between fill-ups while pulling heavy loads and fuel cost savings could recoup the higher investment costs for an LNG truck

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[33] *Ibidem*, p. 85.
[34] European Commission (2014), *Op. Cit.*, p. 14.
[35] European Commission (2011), *White Paper - Roadmap to a Single European Transport Area. Towards a Competitive and Resource Efficient Transport System*, COM(2011) 144, final.

(US$70,000 to US$90,000 compared to diesel) within about three years[36]. The same rationale also applies to LNG-fuelled buses.

Furthermore, LNG is also expected to play an important role as a ship fuel. According to DNV GL, the world's largest classification society, 63 LNG-fuelled ships (excluding LNG carriers) already operate worldwide, while another 76 are on order (as of May 2015)[37]. The key driver behind the choice of LNG as ship fuel relates to its environmental advantages. In fact, ships are generally fuelled by highly polluting fuels such as heavy fuel oil, marine gas oil or distillate fuels. The utilization of LNG allows to significantly reduce local pollution, and thus to safeguard the ecosystems on which ships are operating. This is the reason why the use of LNG as a ship fuel is increasingly encouraged by the authorities of major European harbours, from Rotterdam to Hamburg, from Antwerp to Bremerhaven[38].

Along the same lines, a recent study published by the Oxford Institute for Energy Studies on the prospects of natural gas in the transport sector also concludes that «the answer to the question on whether natural gas is a realistic fuelling alternative [in transport] is yes for heavy trucks and marine, possibly for buses with the case for passenger cars being hardest to make.»[39]

Conclusions: towards a more balanced and secure decarbonisation path

As illustrated in the paper, over the last decade the EU has made consistent progress towards the decarbonisation of its energy system. However, this process has also brought new challenges to the EU energy markets, generating certain paradoxes (such as the parallel growth of renewable energy and coal in the mix) that need to be addressed in order to ensure the sustainability of the EU decarbonisation path.

Considering that after the first rump-up phase - occurred over the last decade - the future integration of more variable renewable energy sources into the system will be more complex both under the technical and economic perspectives, the EU decarbonisation path should indeed now find a more balanced and secure trajectory. In particular, a new EU electricity market design should be able to provide adequate economic incentive for investments in the flexibility options (i.e. network infrastructure expansion, development of smart grids, adoption of demand side measures and development of energy storage technologies) that will be crucial to ensure the sustainability of the EU decarbonisation path also beyond the 2030 horizon.

As the paper illustrated, in order to achieve its 2030 renewable energy target the EU will need to rethink its electricity system beyond renewable energy itself, with a particular focus on the role that natural gas might play in the future of the EU energy system.

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[36] ExxonMobil official website: http://corporate.exxonmobil.com/en/energy/natural-gas/technology/natural-gas-as-a-transportation-fuel?parentId=7bb4486e-b68e-43ee-b9fa-cff1663bd80c

[37] DVN GL (2015), *LNG as a Ship Fuel*, Hamburg.

[38] Reuters (2014), *Global Transport Sector Looks to Ride Natural Gas Boom*, February 5.

[39] Chris Le Fevre (2014), *The Prospects for Natural Gas as a Transport Fuel in Europe*, NG84, Oxford Institute for Energy Studies, Oxford.

Considering its previously illustrated characteristics, and particularly taking into consideration the potential to generate immediate and substantial GHG emissions' reductions by displacing coal with it, natural gas might well play an important role in the future EU decarbonisation path. Its role does not need to be supported by dedicated public policies but, on the contrary, what is needed is a more general EU action aimed at rebalancing the overall energy system along the lines of a truly sustainable decarbonisation path.

Such an action should be carried out by making use of two specific tools: i) Carbon pricing; ii) Environmental regulation.

i) Speeding-up the reform of the Emissions Trading Scheme (ETS)

The development of a well functioning (and technology-neutral) carbon pricing system, able to discourage high carbon options and to promote most cost-efficient ways of reducing GHG emissions, is theoretically the essential component of a sustainable decarbonisation path.

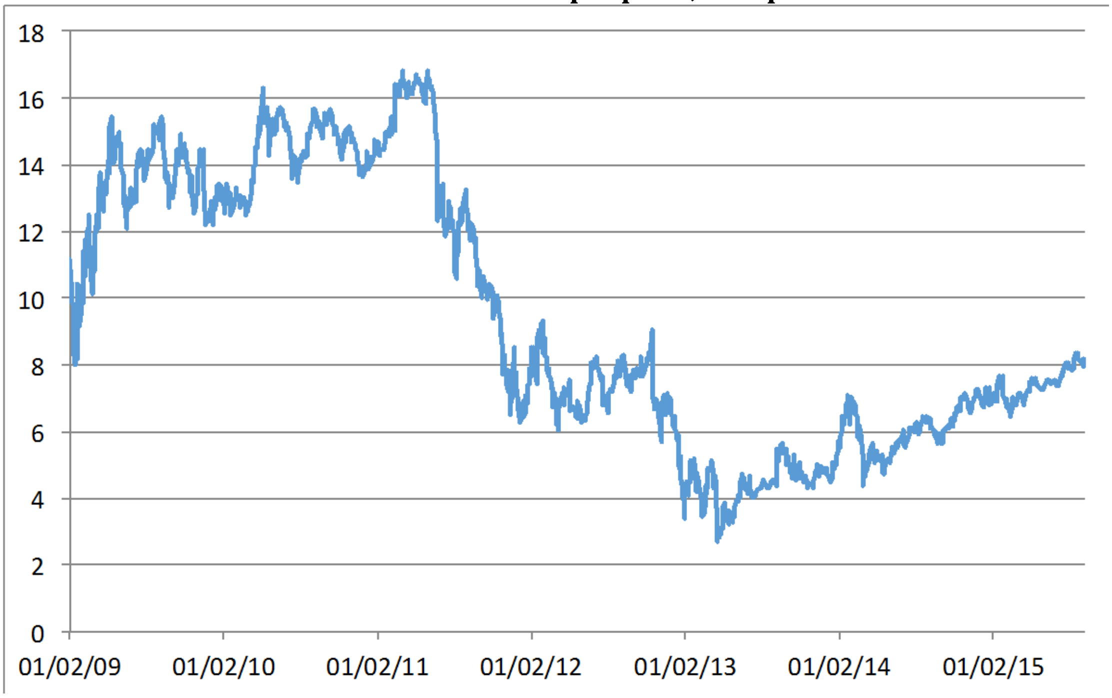
In fact, this system would create the basis of an automatic readjustment of EU electricity markets ideally composed by a progressive phase out of highly polluting coal-fired power plants, a strong development of renewable energy sources (even in absence of incentives) and a larger utilization of natural gas in electricity generation.

In 2005 the EU adopted the Emission Trading Scheme (ETS) as its flagship GHG emissions' reduction initiative. The scheme, based on the "cap and trade" principle, aims at providing appropriate incentives for investments in low-carbon technology via a carbon emissions price[40]. After two initial phases[41], the ETS entered its third trading phase at the beginning of 2013, with the introduction of a EU-wide cap on emissions (reduced by 1.74% each year) and a progressive shift towards auctioning of emission allowances (EUAs) in place of cost-free allocation. However, low levels of industrial output and power generation due to the economic crisis have resulted in an increasingly large surplus of EUAs in the ETS, leading to a significant downward pressure on the carbon emissions price (Fig. 12).

[40] Specifically, the scheme works as follow: the overall volume of GHG that can be emitted each year by the power plants, factories and other companies covered by the system is subject to a cap set at EU level. Within this Europe-wide cap, companies receive or buy emission allowances, which they can trade if they wish. For a detailed overview please refer to: European Commission (2013), *The EU Emission Trading System (EU ETS)*, Climate Action Publications.

[41] 1st Phase, 2005-2007: trading period used for "learning by doing". EU ETS established as the world's biggest carbon market. However, the number of allowances, based on estimated needs, turns out to be excessive; consequently the price of first-period allowances falls to zero in 2007. 2nd Phase, 2008-2012: the number of allowances is reduced by 6.5% for the period, but the economic downturn cuts emissions, and thus demand, by even more. This leads to a surplus of unused allowances and credits, which weighs on carbon price. See: European Commission (2013), *Op. Cit.*

Figure 12
EU ETS carbon emissions spot price, EUR per tonne



Source: own elaboration on European Energy Exchange (2015).

Considering the current inability of the ETS to send sufficient price signals to investors in low-carbon technologies, with the 2030 Climate and Energy Framework the European Commission has brought forward proposals to address the level of over-supply in the ETS and reintroduce a meaningful carbon emissions price[42]. This reform should be seen as the crucial element towards the consolidation of the EU decarbonisation path and, consequently, of the creation of a more balanced EU energy system on which renewables develop in parallel to other low-carbon and flexible solutions, such as natural gas.

ii) Tightening environmental regulation

Considering the numerous challenges related to the development of a well-functioning carbon pricing system at the EU level, the instrument of environmental regulation should also be exploited to rebalance the energy system along the lines of a sustainable decarbonisation path. In particular, tighter emission performance standards should be applied to power plants.

[42] According to the Commission (2014, *Op. Cit.*, p. 8), «the best way to achieve this is to establish a market stability reserve at the start of phase 4 trading in 2021. The market stability reserve would provide an automatic adjustment of the supply of auctioned allowances downwards or upwards based on a pre-defined set of rules and would improve resilience to market shocks and enhance market stability.»

In 2011 the Industrial Emissions Directive (IED)[43] came into force, updating and merging seven pieces of existing legislation, including the previously illustrated Large Combustion Plant Directive (LCPD).

The new IED places further restrictions on the level of nitrogen oxides, sulphur dioxide and particulate emissions permitted from power generators after 1 January 2016 (as until the end of 2015 the provisions of LDPD are applied)[44].

It is difficult to envisage whether these provisions will have or not a consistent impact on the European coal-fired power plants fleet. This will largely depend on the materialization of the incentive to invest in depollution equipment, a choice set to be driven by technology cost and coal pricing itself. According to Cedigaz (2014), for old coal-fired power plants there will be no incentive to invest in depollution equipment and 50-55 GW of EU coal power capacity may thus close by 2020/2023 at the latest according to the IED[45]. However, other analyses carried out by European climate think-tanks suggest that a predominant share of EU coal power plants will become IED compliant, as technological changes and flexibility in IED rules will make compliance much less costly than previously estimated[46].

The implementation of the IED should thus be followed closely, also through the system of review already adopted by the European Commission. At the same time, the EU should be ready to take further actions on environmental regulation, in order to ensure the achievement of proper environmental standards in the EU power plants fleet.

Carbon pricing and environmental regulation constitute the optimal tool-set to calibrate the energy system along the lines of a sustainable decarbonisation path. If correctly utilized, these tools could stimulate a further development of renewable energy sources, a greater role of natural gas in the energy mix and a reduction in the utilization of polluting coal, at one fell swoop. This readjustment seems to be the only way to make decarbonisation balanced and secure up to 2030 and beyond.

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[43] Official Journal (2010), *Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on Industrial Emissions (Integrated Pollution Prevention and Control)*, L 334, 17.12.2010.

[44] In particular, in comparison with the previous LCPD the new IED tightens emission limit values (ELVs) for sulphur dioxide from a level of 400 milligrams per cubic metre (mg/Nm3) to a level of 200 mg/Nm3. Furthermore, power generators will have to install selective catalytic reduction from 2016 to meet the nitrogen oxides ELVs. Peaking plants (<1,500 annual operating hours) can run indefinitely, a Transitional National Plan to mid-2020 allows trading in most pollutant categories to achieve emissions reductions equivalent to the Directive's ELVs, and a derogation allows operators to run their plants for just 17,500 hours after 1 January 2016 before closure, which must be before the end of 2023.

[45] Cedigaz (2014), *Gas and Coal Competition in the EU Power Sector*, Rueil Malmaison.

[46] In particular, Sandbag (a UK-based climate think-tank) estimates that across the EU 110 out of 150 GW are or will become IED compliant. The remaining 40 GW could become compliant too if it invests in NOx abatement. According to the analysis, it had been thought that the only way to comply would be to install selective catalytic reduction that turns NOx into nitrogen and water. However, cheaper options such as selective non-catalytic reduction have became available in the meantime. See: Sandbag (2014), *Europe's Failure to Tackle Coal - Risks for the EU Low Carbon Transition*, London.

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