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ELECTRICITY FOR EUROPE

Power Statistics & Trends 2012

SYNOPSIS

The **Union of the Electricity Industry – EURELECTRIC** is the sector association representing the common interests of the electricity industry at pan-European level, plus its affiliates and associates on several other continents.

In line with its mission, EURELECTRIC seeks to contribute to the competitiveness of the electricity industry, to provide effective representation for the industry in public affairs, and to promote the role of electricity both in the advancement of society and in helping provide solutions to the challenges of sustainable development.

EURELECTRIC's formal opinions, policy positions and reports are formulated in Working Groups, composed of experts from the electricity industry, supervised by five Committees. This "structure of expertise" ensures that EURELECTRIC's published documents are based on high-quality input with up-to-date information.

For further information on EURELECTRIC activities, visit our website, which provides general information on the association and on policy issues relevant to the electricity industry; latest news of our activities; EURELECTRIC positions and statements; a publications catalogue listing EURELECTRIC reports; and information on our events and conferences.

EURELECTRIC pursues in all its activities the application of the following sustainable development values:

Economic Development
- Growth, added-value, efficiency

Environmental Leadership
- Commitment, innovation, pro-activeness

Social Responsibility
- Transparency, ethics, accountability

December 2012

Contents

Key Messages 2011-2012

1 Electricity demand on the rollercoaster

After a decade of growth and a partial recovery in 2010 after the economic crisis of 2009, electricity demand fell again in 2011 as the European economy struggled with the prolonged sovereign debt crisis (*Figure 1* and *Table 1*). Amid these changing macro-economic conditions, but also in light of the on-going transition of the energy system at large forecasting electricity demand up to 2020 is proving extremely difficult and, sometimes, erratic. As a consequence, demand forecasts have been revised downwards compared to last year's edition.

2 Low-carbon capacity remains on the rise

The EU's renewables capacity increased yet again in 2011, reaching 34% of total installed capacity (*Figure 7*). About 25 GW – including hydro – were connected to the European electricity grids in both 2010 and 2011. In the context of a shrinking demand, it would appear that these new renewable capacities have been set up as the result of subsidies rather than demand incentives. While the attention of the general public focused on the effects of Fukushima and the subsequent German decision to phase out nuclear power, nuclear capacity in all other member states actually grew by almost 1 GW between 2010 and 2011.

3 Renewables output continues to grow but unfavourable weather reduces hydropower output

Electricity generated from hydropower decreased by 57 TWh or 17% in 2011 compared to 2010 (*Figure 8*). The substantial decrease was driven by adverse hydrological conditions, particularly in southern Europe. However, the drop in hydropower was partially compensated by other renewable plants (+47 TWh or +16%).

4 More than half of power generation will be low-carbon by 2020

Renewables progressively move to the centre of electricity systems and both capacity and generation are expected to be substantially higher in 2020 than today (*Figures 7* and *8*). By 2020 45% of all power plants will be renewable-based, generating some 31% of Europe's electricity. Low-carbon electricity from nuclear and renewables will account for 56% of all electricity generated.

5 Increased variability calls for a holistic, a system approach

The importance of variable renewables like wind and solar (*Tables 2* and *3*) is making a holistic approach to managing the power system increasingly urgent. A portfolio of options is available to back up renewables, from interconnections between power systems – as exemplified by the Nordic region in *Figures 10* and *11* – to (large-scale hydro and pumped) storage, flexible generation and demand-side participation.

What is
Power Statistics?

The 2012 edition of EURELECTRIC's *Power Statistics* gathers the latest available data from the electricity sector, including forecasts up to 2030.

The data cover the years 1980, 1990, 2000, 2009, 2010, as well as forecasts for 2020 and 2030. The report also includes preliminary data for 2011, which were first published in a leaflet at the occasion of the EURELECTRIC Annual Convention in Malta in June 2012.

The data are provided by EURELECTRIC members from all 27 EU member states, as well as from Switzerland, Norway and Turkey. As from 2011, we also gather data from Energy Community members. We are pleased to present data for Croatia, Bosnia-Herzegovina, Serbia and Ukraine, and intend to include the other states of the region in the next years.

The data cover:

- the structure of the electricity industry;
- trends in general economic indicators;
- peak demand and load management;
- medium and long-term generating prospects;
- sectorial electricity consumption;
- electricity balances;
- fuel consumption in and emissions from the electricity sector.

This synopsis of the full *Power Statistics* report provides an overview of key messages and data. They are primarily based on EURELECTRIC's own statistics, as supplied by EURELECTRIC's Group of Experts on Statistics & Prospects. These statistics reflect the national situation and prospects as perceived by each country. In particular, the forecasts are not necessarily official national forecasts (by governments, electricity associations or transmission system operators), but may be considered as 'best engineering estimates' of the group members, based on an annually updated picture of the respective national planning and forecast situation.

In addition, the report refers to other relevant publications where necessary to identify the main power sector trends for the reporting period. Wherever we use such information, the source is clearly indicated.

Finally, and further to last year's successful experience, this year's edition of *Power Statistics* once again includes a special contribution from EURELECTRIC's partner VGB PowerTech on the availability/unavailability of power plants. We are also pleased to integrate a full section on the Energy Community countries from the Western Balkans, members of EURELECTRIC.

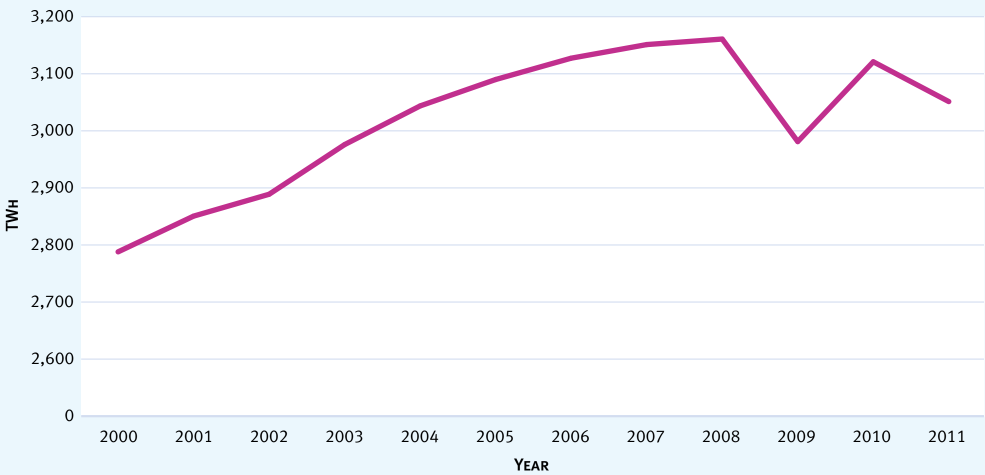
1 The energy transition in times of recession

Where does the European electricity sector stand? What are today's major debates in an overall environment of recession that is putting huge pressure on the promised low-carbon transition towards 2050?

The **continuing economic downturn is placing manifold constraints on the power sector:** uncertain medium- and long-term perspectives, a drop in electricity demand, deteriorating borrowing conditions on the capital markets, volatile regulation, and sudden or retroactive changes to regulatory frameworks and tax regimes are only some of the consequences.[1] The vicious downwards spiral of 'recession' ➔ 'demand drop' ➔ 'lack of investment' is affecting many generation technologies, extending from conventional technologies to even some renewables. According to Bloomberg New Energy Finance, investment in clean energy – renewables but also other technologies like smart grids – was down in 2012 for the first time in eight years, adding to existing doubts about the future growth of such investments.[2]

After the shock triggered by the financial crisis of 2008, the EU economy had recovered somewhat in 2010. However, the prolonged sovereign debt crisis continues to haunt the European capitals, sparking fears of a double-dip recession.

Figure 1: Electricity demand (including network losses) in the EU 27, 2000-2011



Source: EURELECTRIC, Power Statistics (various editions)

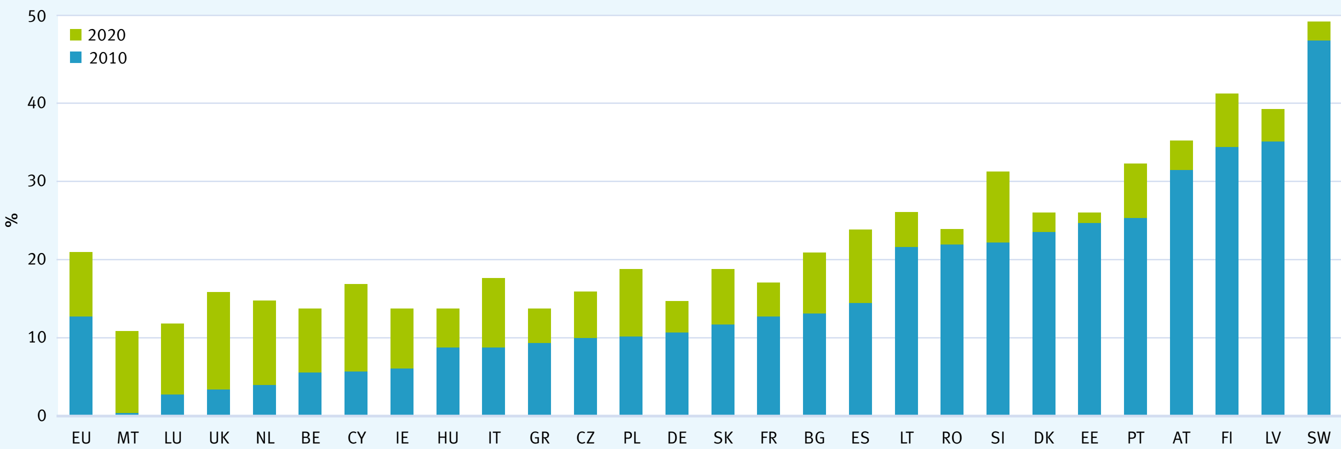
[1] EURELECTRIC, Powering Investments: Challenges for the Liberalised Electricity Sector – Findings and Recommendations, December 2012.

[2] Bloomberg New Energy Finance: World clean energy investment heading for a drop in 2012, after mediocre Q 3, BNEF 2012. The global decline as quoted by Bloomberg is 20%.

Electricity demand has mirrored GDP patterns: after recovering in 2010 it has shrunk again in 2011, although not hitting the low of 2009 (*Figure 1*). While it is true that 2010 was a fairly cold year compared to the milder winter of 2011, preliminary information from the statistical offices of different EU countries suggests a further decrease in demand for 2012 – so the weather might be an element, but the crisis appears to be the main reason for the observed demand drop.

Despite the reduction in electricity demand **RES deployment has continued in 2011**. This is a result of various national support schemes – in particular for solar photovoltaic and wind onshore – but also of constant technological improvement, decreasing prices (in the case of photovoltaic also due to a supply glut) and greater supplier competition, which have all led to successful cost reductions. According to the European Commission, the EU is on track to meet its 2020 renewables target (*Figure 2*). But in 2012 some parties also voiced doubts: the crisis could oblige member states to downsize their renewables policies and thus jeopardise the implementation of the National Renewable Energy Action Plans.

Figure 2: Comparison between EU member states' 2020 renewable target and interim 2010 targets



Source: European Commission

Figure 3: Evolution of European policies in the field of energy 2011-2013

Source: EURELECTRIC 2012

Policy trends

What is on the EU's regulatory and legislative agenda in the reported period? *Figure 3* shows the main legislation on energy for the period 2011-2013.

As a forward-looking exercise and part of a set of three EU roadmaps (on climate, transport and energy), the European Commission's DG Energy presented the **Energy Roadmap 2050** in late 2011. Although its general approach was welcomed by industry, there was a general impression that the roadmap focused predominantly on targets rather than frameworks.

2012 was marked by the release of **two Communications** by the Commission: on **renewables development after 2020** and on the **Internal Energy Market**, to be completed by 2014 according to the European Council. Entering the final stretch of its mandate running until 2014, the current Commission is still considering whether to push for a new policy initiative for the post-2020 period, similar to the 2009 energy and climate package that set the 20-20-20 objectives. Conflicts over the next long-term EU budget, the Multiannual Financial Framework 2014-2020, also touch upon energy: the proposed Connecting Europe Facility would make available €9.1 billion for the completion and improvement of European energy infrastructure, while the so-called Horizon 2020 programme would focus research and development. Meanwhile the question how to empower **the EU Emissions Trading Scheme** (ETS) to deliver low-carbon investment has triggered a proposal from DG Climate Action to 'backload' allowances from the first years of trading phase 3 to the last three years, i.e. 2017-2020.

Energy efficiency remains high on the list of priorities for the EU and its member states going forward. The Energy Efficiency Directive (EED), which details the measures needed to hit the EU's 20% energy efficiency target for 2020, was formally adopted in October 2012. It is still too early to judge the Directive's real contribution, which will strongly depend on how member states transpose and implement it. As a matter of fact, governments have a certain degree of flexibility and could opt for different pathways to reach the agreed targets.

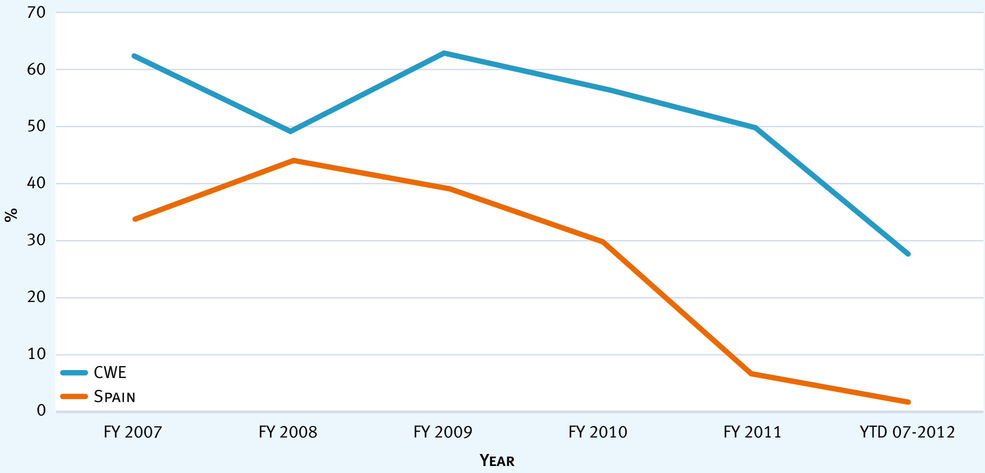
Market design has been one of the buzzwords of the year. Conventional power plants have been running far less than planned – with the extreme case of CCGTs running between zero and 2,000 hours yearly (*Figure 4*). Reasons include *inter alia* the increase of wind and solar photovoltaic and the fact that the latter cuts across peak hours when CCGTs were meant to run, decreasing demand as explained above, and substitution effects between coal and gas depending on commodity and emission allowance prices.

According to UBS Investment Research 22 GW of old thermal capacity in Central Europe is loss-making.[3] The logical response would be to phase out these plants at the next maintenance session. But regulators, TSOs, generators and policymakers agree that they might be needed for balancing and system stability purposes for at least the next two decades, forcing them to nevertheless remain operational.

Multiple questions arise when assessing current market frameworks and mechanisms: how can economically non-viable plants remain in the system to guarantee generation adequacy and system stability? How can this be achieved with the least distortive impact on the market? To date, EU member states present a very fragmented picture (*Figure 5*). It is thus crucial that strategic reserves or other mechanisms, if introduced, at least fulfil some common European criteria that make them compatible with other EU member states and do not undermine the creation of the Internal Energy Market.

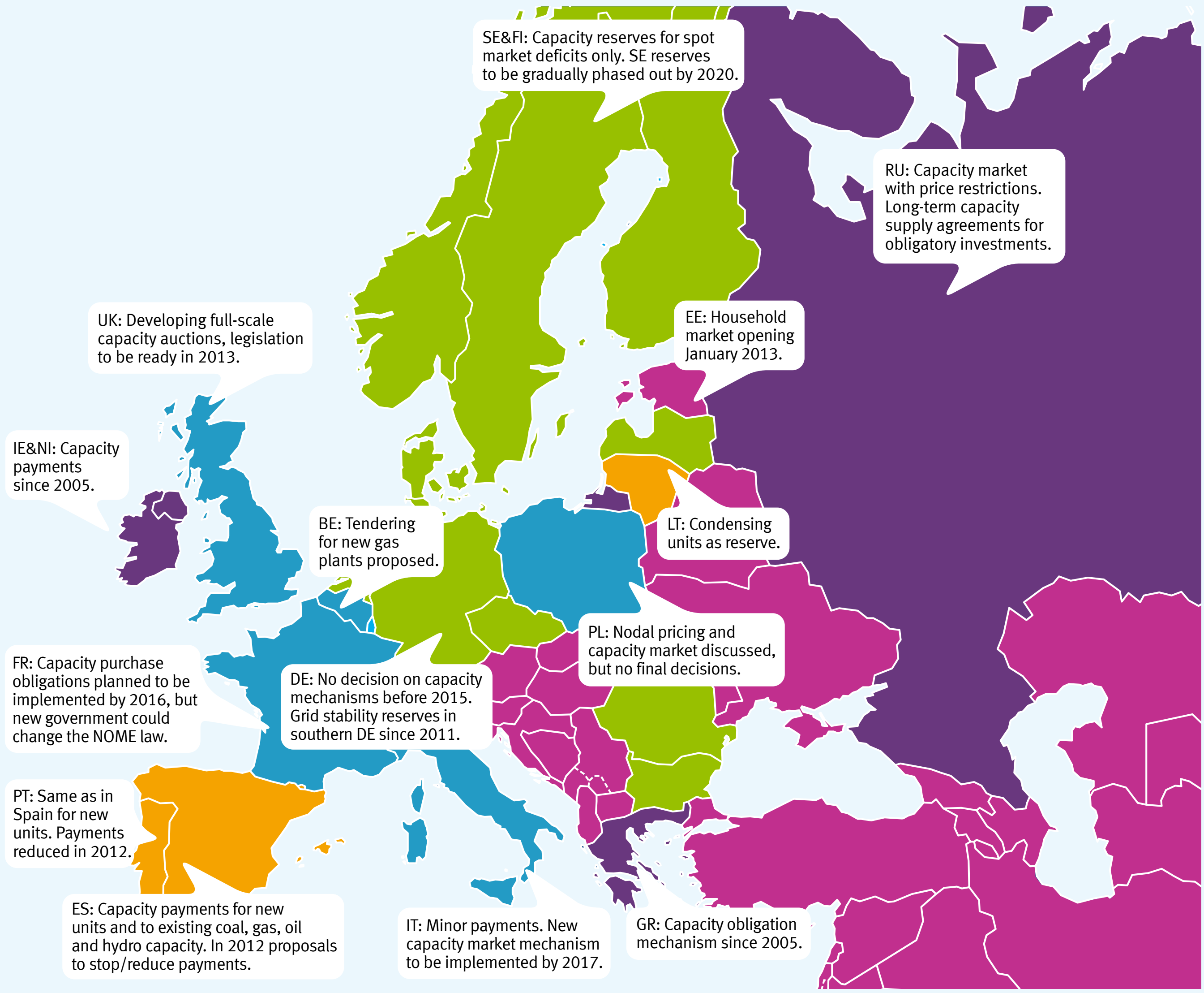
[3] Hummel, Patrick, Intervention to keep prices lower for longer. UBS Investment Research European Utilities. 5.9.2012:3.

FIGURE 4: RUNNING HOURS OF CCGTS IN SPAIN AND CENTRAL-WESTERN EUROPE



Source: EURELECTRIC

FIGURE 5: HUGE VARIETY OF MARKET DESIGNS ACROSS EU MEMBER STATES



- Energy-only market*
- Partial capacity mechanisms
- Proposal for new capacity elements
- Major capacity mechanism
- Regulated market restrictions

* No capacity payments to power plants in the day-ahead and intraday markets, but balancing market reserve capacity is contracted in advance.

Source: EURELECTRIC

2 Demand trends

Table 1 shows the evolution of electricity demand for 2009-2011 and 2020 per member state.

Table 1: Evolution of electricity demand and year-on-year changes in the EU-27 (TWh)

Country	2009	2010	2011	2020	Year-On-Year 2010/2009	Year-On-Year 2011/2010	Annual Growth Rate 2020/2010
Austria	64.0	65.0	66.8	72.8	1.6%	2.8%	1,2%
Belgium	83.6	90.4	86.0	94.3	8.1%	-4.9%	0,4%
Bulgaria	30.4	32.5	31.3	52.7	6.9%	-3.7%	6,2%
Cyprus	4.7	4.8	5.0	6.4	2.8%	4.6%	3,4%
Czech Republic	61.6	63.7	65.2	77.5	3.4%	2.4%	2,2%
Germany	534.8	565.0	565.8	507.0	5.6%	0.1%	-1,0%
Denmark	34.0	34.7	34.7	38.2	2.1%	0.0%	1,0%
Estonia	8.7	8.3	7.8	10.1	-4.9%	-5.8%	2,2%
Spain	274.0	278.0	273.1	340.0	1.5%	-1.8%	2,2%
Finland	81.3	87.7	84.4	99.0	7.9%	-3.8%	1,3%
France	486.7	513.2	478.2	523.1	5.4%	-6.8%	0,2%
United Kingdom	347.0	354.0	342.3	346.0	2.0%	-3.3%	-0,2%
Greece	58.9	59.2	58.6	63.9	0.5%	-1.0%	0,8%
Hungary	38.9	39.8	40.2	47.0	2.3%	1.0%	1,8%
Ireland	25.1	25.4	26.8	31.4	1.2%	5.5%	2,4%
Italy	320.3	330.5	332.3	370.0	3.2%	0.5%	1,2%
Lithuania	10.2	10.3	10.4	13.3	1.0%	1.0%	2,9%
Luxembourg	6.2	6.7	6.6	7.2	7.9%	-1.3%	0,8%
Latvia	7.0	7.3	7.2	8.9	4.3%	-1.4%	2,2%
Malta	2.0	2.0	2.2	2.4	-2.7%	9.1%	2,1%
Netherlands	114.1	117.1	118.1	131.7	2.6%	0.9%	1,2%
Poland	135.9	141.6	145.8	171.8	4.2%	3.0%	2,1%
Portugal	52.6	55.0	53.1	52.0	4.6%	-3.5%	-0,5%
Romania	55.2	50.6	52.3	64.2	-8.3%	3.3%	2,7%
Sweden	137.9	147.0	139.2	146.4	6.6%	-5.3%	-0,04%
Slovenia	12.3	16.1	12.6	14.9	30.9%	-21.7%	-0,7%
Slovakia	25.4	26.6	26.8	35.2	4.7%	0.8%	3,2%
	3,012.8	**3,132.5**	**3,072.8**	**3,327.4**	**4.0%**	**-1.9%**	**0,6%**

Source: EURELECTRIC, Power Statistics (various editions). Data source for 2020 for Italy and Malta is GlobalData's Power E-Track

Electricity demand is forecast to grow throughout the entire observation period in Europe, albeit not in all countries and at lower rates compared to previous estimates. Overall demand in the EU is assumed to grow by 0.6% p.a. until 2020, reaching 3,327 TWh from 3,132 TWh in 2010. It is interesting to note, however, that this year's forecast is considerably lower than the forecast we made in our 2011 edition, where demand in 2020 stood at 3,467 TWh. This shifting of expectations can be explained *inter alia* by the worsening of the economic crisis in 2011 or by the increased role of energy efficiency policies being developed throughout Europe.

Demand is not expected to rise equally everywhere in Europe. Growth will be particularly sustained in Bulgaria, where electricity demand will increase by 6.2% p.a., and in several other countries, including Cyprus (+3.4% p.a.), Slovakia (+3.2% p.a.), Lithuania (+2.9% p.a.) and Romania (+2.7% p.a.). It will achieve double-digit numbers in the majority of member states, whereas it will proceed more slowly in Luxembourg (+0.8% p.a.), Denmark (+1% p.a.), Belgium (+0.4% p.a.) and France (+0.2% p.a.).

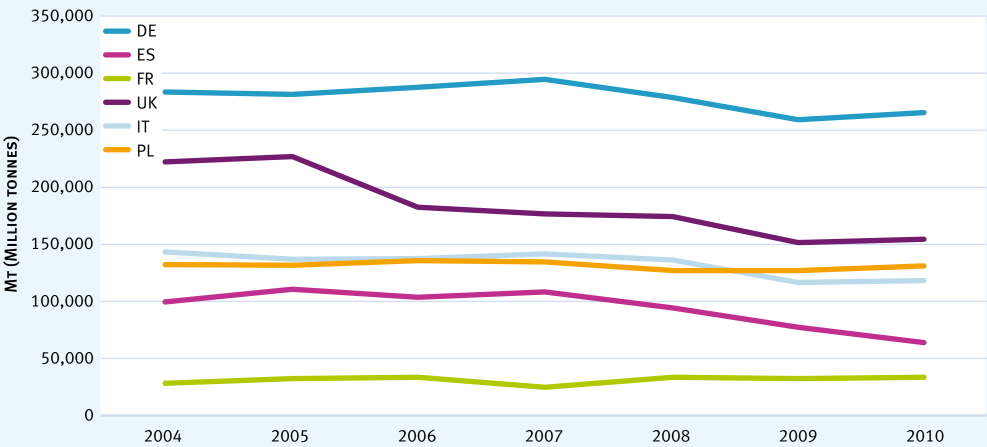
Yet there are exceptions to this trend of growing electricity demand. The most remarkable is without doubt Germany, where in line with the requirements of the *'Energiewende'* (energy transition), total electricity demand is set to decrease by about 1% p.a., from 565 TWh in 2010 to 507 TWh in 2020. Indeed, the trend is set to continue until 2030, when demand is expected to stand at 474 TWh. Other countries with a decreasing electricity demand include Slovenia (-0.7% p.a. until 2020 compared to 2010), Portugal (-0.5% p.a.), and Great Britain (-0.2% p.a.). Growth will be almost nil in Sweden (-0.04% p.a.).

3 Sustainability

The challenge of reducing SO_2 and NO_x emissions has been taken up successfully by the industry during the 1990s and the first decade of the 21st century, with emission reductions of 62% between 1990 and 2007 for SO_2 and 39% for NO_x, despite an increase of electricity generation and heat by 32% in the same period.[4] The deployment of abatement techniques and the switch from coal- and oil-fired generation to gas-fired generation are the main factors behind this trend.

Today, the European emissions concerns have largely shifted from SO_2 and NOx to CO_2, although the necessity of reducing NO_x and SO_2 emissions will continue to prompt the closure of fossil-fired power plants until 2023. The electricity and heating sectors are responsible for nearly 30% of all greenhouse gas emissions in Europe, with CO_2 predominant. But although electricity generation increased by roughly one third, the corresponding increase of CO_2 has been less than 1%. Thus there is a clear decoupling between demand increase and emissions. Due to some missing data, we could not present in this report aggregated EU-27 CO_2 emissions from electricity generation. We thus selected a sample of EU countries (DE, ES, FR, IT, PL, UK), rather representative in terms of variety of energy mixes and generation sizes existing in Europe. Data refer to the period 2004-2010. We observe here the following overall picture: 2004-2007 is characterised by a stabilisation of the level of CO_2 emissions, whereas the period 2007-2010 shows a clear trend of CO_2 reduction despite increased generation (*Figure 6* & *Table 2*). This trend has also been confirmed by the European Environment Agency and is representative for EU at large.

Figure 6: Electricity-related CO_2 emissions for some specific EU countries between 2004 and 2010 (in Mt)



Source: EURELECTRIC, Power Statistics (various editions)

[4] Source: European Environment Agency 2012:www.eea.euroa.eu/data-and-maps/indicators/emissions-co2-so2-nox-from-1/assessment.

4 Trends by technology

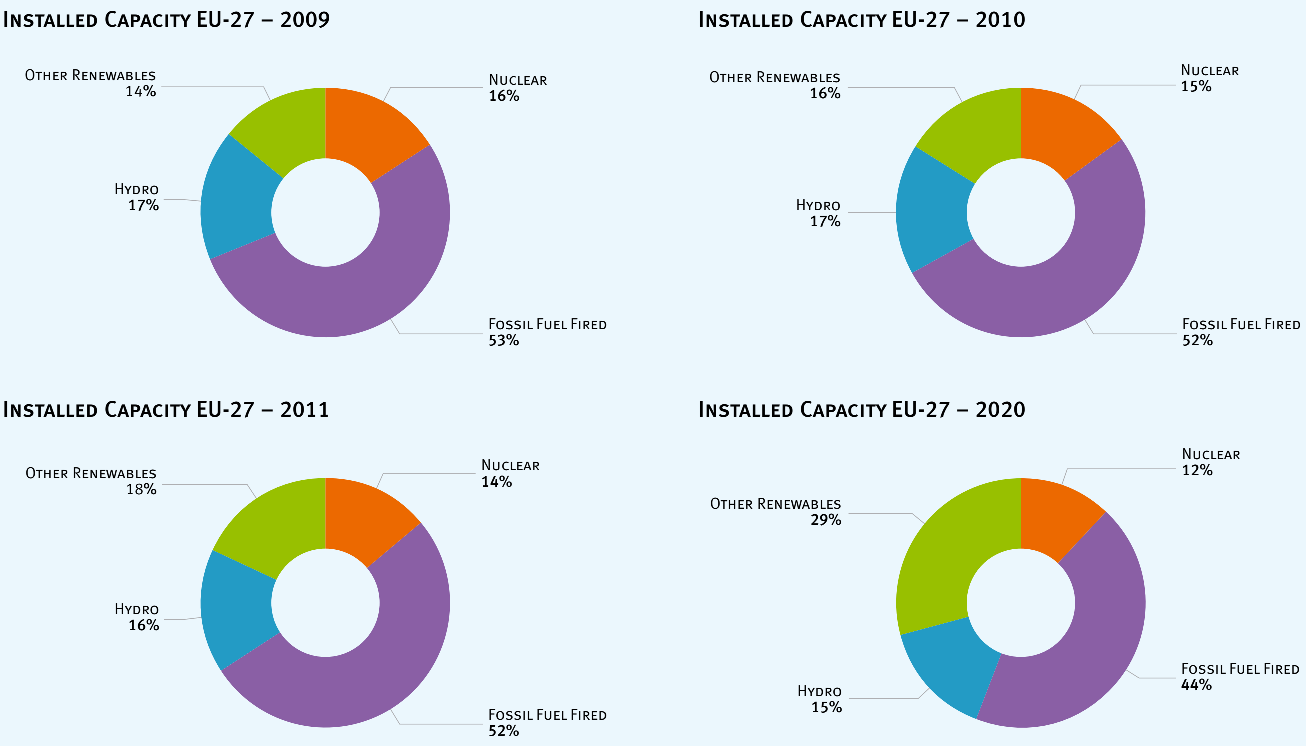
In line with the EU's 20-20-20 targets, renewables are being deployed on a massive scale across the EU, as shown in the figures below. Renewable installations grew steadily between 2009 and 2011, with an average of 25 GW – including hydro – being added each year. As a result, renewable energies account for 34% of the total installed capacity at the end of 2011, up from 31% in 2009 and 33% in 2010.

The installed capacity of nuclear power plants changed in 2011 primarily because of the immediate closure of 8.4 GW of German nuclear capacity following the Fukushima accident in March 2011, which prompted the government to pass a phase-out bill that will see the country abandoning nuclear energy by 2022. In all other member states using nuclear power except France and the United Kingdom, the installed capacity actually grew slightly (0.8 GW) between 2010 and 2011, mainly due to repowering. Nuclear power plants now account for 14% of the total installed capacity in the EU.

Although a total of 1 GW of new fossil-fired power plants went on-stream in 2011, their share of the total installed capacity – about 52% – did not change because of the simultaneous addition of new renewables capacity.

Looking ahead towards the end of the decade, renewables are set to overtake fossil fuel as largest generation technologies, reaching 44% of total installed capacity. Together with nuclear, hydro and other renewables will provide a low-carbon power plant base of 56% of installed capacity by 2020.

Figure 7: Evolution of installed capacity in the EU-27



Source: EURELECTRIC, Power Statistics 2012

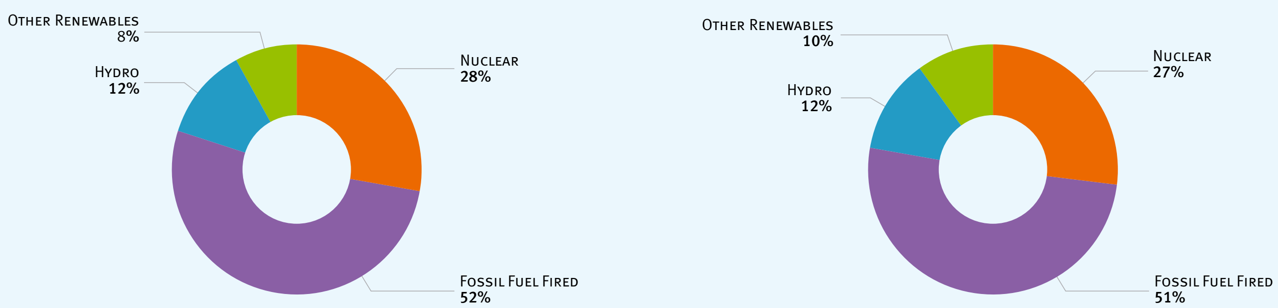
However, this continued trend towards greater renewable penetration is not as straightforward if one looks at actual electricity generation rather than capacity alone. In 2011 renewable electricity (including hydro) represented 22% of total electricity generation – the same as in 2010 although up two points compared to 2009. This is primarily due to the decreasing hydropower generation in 2011, from 390 TWh to 332 TWh (-17%), resulting from unfavourable weather conditions across Europe. Notable national cases of decreased hydro generation include Spain (12.3 TWh less, or -27%), Portugal (4.4 TWh less, or -27%) and Italy (6.7 TWh less, or-12%); these three cases alone account for a third of the reduction (23.4 TWh). The drop in hydro was partially compensated by increased generation from other renewable sources, which now accounts for 11% of total generation (compared to 8% in 2009 and 10% in 2010).

Nuclear generation was down by 1.8% in 2011 compared to 2010. However, due to the reduction in overall generation and the poorer performance of renewables, the share of nuclear in the overall generation mix remained stable year-on-year. Similarly, fossil-fired generation was down by 50 TWh (-3% year-on-year) but its overall contribution to total generation remained stable year-on-year.

Looking towards 2020, the structure of the sector will change towards increased renewable generation, with renewables other than hydro more than doubling from 340 TWh in 2011 to 708 TWh in 2020. By 2020, the share of total low-carbon electricity generation will be 56%.

Figure 8: Evolution of electricity generation in the EU-27

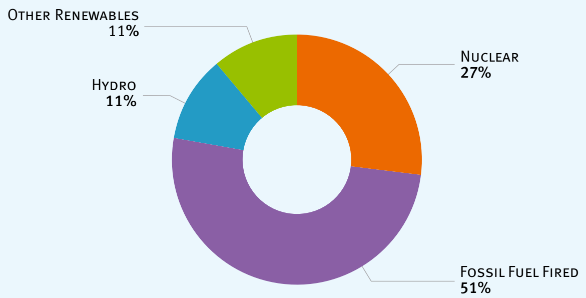
Electricity Generation EU-27 – 2009 | **Electricity Generation EU-27 – 2010**



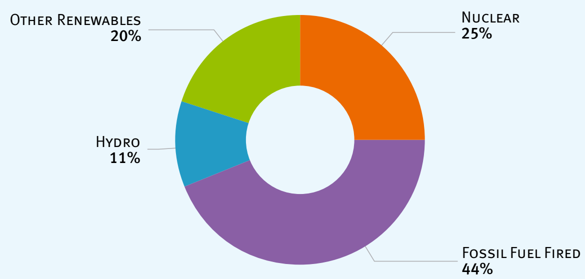
Source: EURELECTRIC, Power Statistics 2012

Compared to last year's forecasts, we see renewables other than hydro contributing to 20% of total electricity generation by 2020 (last year our forecast was 19%), while hydro remains stable at 11%. The changed forecast for non-hydro renewables is complemented by a similar change for nuclear (25% this year against last year's 24%). Such increases take place at the expense of fossil fuel generation, which sees its share fall to 44% compared to the 46% of last year's forecast. It is interesting to note though, that although the nuclear share of total generation changes, absolute nuclear generation in 2020 will be in the same order as in 2011 (about 870 TWh).

Electricity Generation EU-27 – 2011



Electricity Generation EU-27 – 2020



5 Flexibility: Renewables and balancing

The considerable increase of variable renewables (v-RES) in Europe is creating new challenges for the operation of the European power systems. Variable renewables are inherently non-dispatchable, i.e. cannot be controlled by power plant owners/operators. They hence require a holistic approach to ensure they are deployed in a technically sound and cost-effective way.

Germany is a case in point. *Table 2* shows German v-RES data that can help explain the need for flexibility and a system approach.

Table 2: Variable RES indicators in Germany (year-end 2011)

	Wind[5]	Photovoltaic[7]	Wind + PV[7]
Total installed capacity	29,075 MW	24,990 MW	54,065 MW
Maximum generation[6]	22,795 MW (78%)	13,939 MW (56%)	26,479 MW (49%)
Minimum generation[8]	266 MW (0.9%)	0 MW (0%)	402 MW (0.7%)
Average generation[8,7]	5,145 MW (18%)	4,390 MW (18%)	7,374 MW (14%)
Maximum increase within 1 hour	4,348 MW	3,319 MW	4,348 MW
Maximum increase within 5 hours	7,744 MW	12,228 MW	13,907 MW
Maximum decrease within 1 hour	-4,723 MW	-3,299 MW	-4,723 MW
Maximum decrease within 5 hours	-8,507 MW	-11,863 MW	-14,966 MW

Source: BDEW

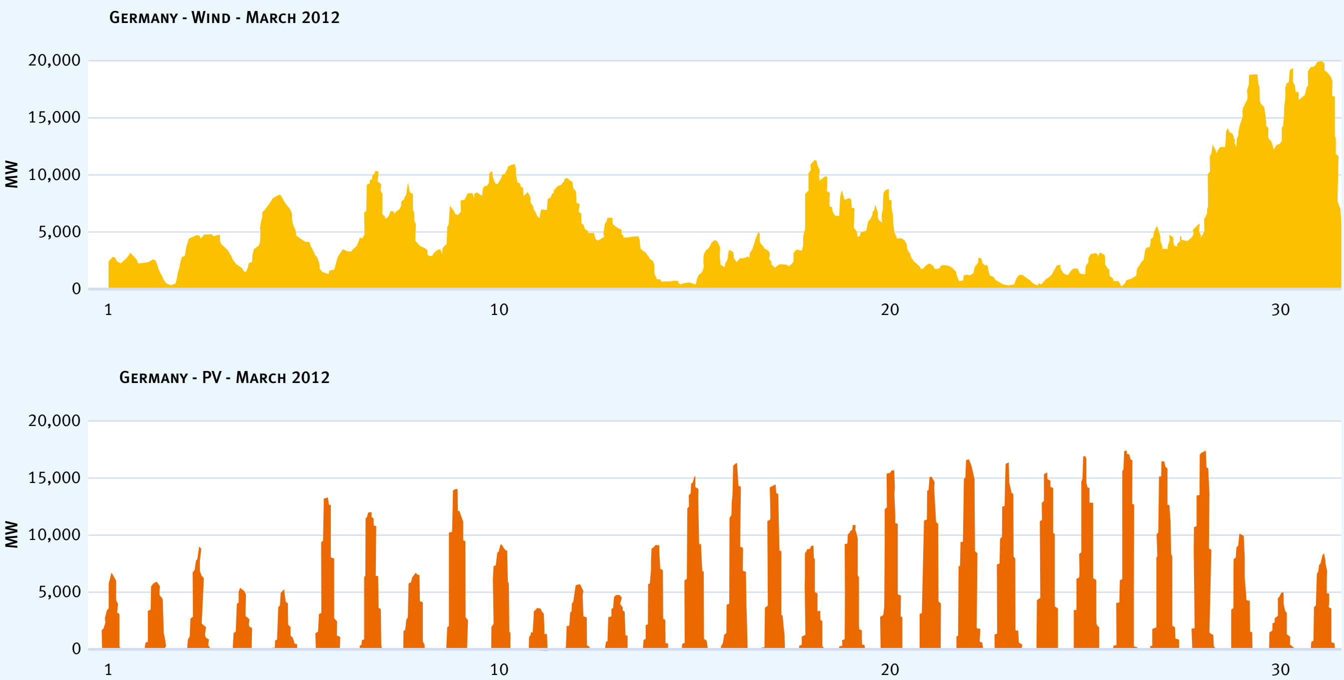
[5] The numbers in parentheses in the second, third and fourth rows show maximum, minimum and average generation as a percentage of the total installed capacity given in the first row.

[6] Maximum generation, minimum generation and average generation do not refer to actual generation (expressed in kWh or its multiples) but to the number of wind farms or photovoltaic installations (or aggregated) that were simultaneously feeding electricity into the grids at a given time (expressed in MW).

[7] Average generation for photovoltaic refers to peak load time, i.e. between 8h00 and 20h00.

[8] The 0% should not mislead the reader; as explained in the preceding footnote, the value does not cover off-peak hours, i.e. the hours between 20h00 and 8h00. In other words, there are days when photovoltaic contribution to the grid during peak hours is nil.

Figure 9: Wind and PV patterns in Germany, March 2012



Source: http://www.theoildrum.com/node/9205, retrieved 5 October 2012

At the end of 2011, 29,075 MW (or 17% of total installed capacity) of wind farms were connected to the German grids. Photovoltaic installations stood at 24,990 MW (or 15% of total installed capacity). In other words, 32% (54,065 MW) of the total installed capacity in Germany was based on v-RES.

The difficulties in predicting when and how much electricity from such sources is actually available are obvious. The maximum and minimum generation values in *Table 3* show the variability of wind power and PV. In 2011, the contribution of v-RES to generation ranged between 1% and 78% of total installed wind capacity and between 0% and 56% of total installed photovoltaic capacity respectively. Another way of interpreting these figures would be to look at the average generation. Out of a total capacity of 29,075 MW for wind and 24,990 MW for photovoltaic, the average capacity generating electricity was 18% for both wind and photovoltaic (and 14% if aggregated). These average generation figures reinforce the idea that v-RES capacity is only partly used most of the time. Other forms of generation continue to be needed to keep the balance between supply and demand of electricity.

Yet even if average generation is still low, v-RES nevertheless introduce challenges to the normal operation of power systems as *Table 2* also shows. In particular, they increase the requirements for flexibility in the system to cope with sudden increases or decreases of v-RES output.

In 2011, the maximum ramp-up of wind farms (i.e. the increase in output) was 4,348 MW within 1 hour and 7,744 MW within 5 hours. Conversely, the maximum decrease was by 4,723 MW and 8,507 MW in 1 hour and 5 hours respectively. Photovoltaic experienced a maximum ramp-up of 3,319 MW within 1 hour and 12,228 MW within 5 hours and a drop of 3,299 MW in 1 hour and 11,863 MW within 5 hours.

Note that the described ramping can either occur simultaneously or peaks in v-RES generation can be unrelated – as shown in *Figure 9* towards the end of March 2012, when wind generation in Germany was sustained and the contribution from photovoltaic was limited compared to the preceding weeks.

Once aggregated, the numbers in *table 2* describing the ramping are even more striking: taken together, photovoltaic and wind ramped up by a maximum of 4,348 MW within 1 hour and 13,907 MW within 5 hours and down by 4,723 MW and 14,966 MW in 1 hour and 5 hours respectively.[9]

These numbers clearly highlight the magnitude of the v-RES challenge: photovoltaic installations and wind farms ramp up and down according to the availability of wind and sun. Such ramping is inherently less predictable and creates pressure on the remainder of the generating fleet to keep the lights on with a decent power quality (e.g. voltage, frequency). This pressure is increased by the fact that v-RES, unlike other generators, are not exposed to market dynamics such as electricity demand, consumer behaviour or balancing requirements.

Flexible and back-up capacity is not the only tool available to compensate for the variability of v-RES. As demonstrated in our report *Flexible generation: backing-up renewables*, interconnectors and (hydro) storage are also key to integrate v-RES, as exemplified by the increased penetration of wind in Denmark.

In Denmark, total installed capacity of wind reached 3,949 MW by the end of 2011, corresponding to 29% of the overall installed capacity (*Table 5*). The maximum contribution from wind stood at 3,520 MW, which corresponded to 89% of total wind capacity, whereas the minimum was a scanty 1 MW (or 0.03%). On average, Danish wind farms were feeding 1,114 MW of electricity into the grid in 2011.

What is specific to the Danish situation is the availability of Norwegian and Swedish hydro storage that can be used in Denmark due to the high interconnectivity between these countries. The following figures are snapshots of wind generation in Denmark and the usage of interconnections with its northern neighbours. They show the shift in cross-border electricity flows between the Scandinavian countries further to changes of wind generation in Denmark.

Table 3: Wind indicators in Denmark (year-end 2011)

	Wind
Total installed capacity	3,949 MW
Maximum generation	3,520 MW (89%)
Minimum generation	1 MW (0.03%)
Average generation	1,114 MW (28%)

Source: EURELECTRIC and Energinet.dk

[9] The aggregated data are not a sum of the previously mentioned (separate) ramps of photovoltaic and wind since those may have occurred separately. It rather represents the combined ramps of photovoltaic and wind in any single moment as registered by the transmission system operators (TSOs).

Figure 10: Wind generation in Denmark and interconnection patterns between Denmark, Norway and Sweden, 25-31 December 2011

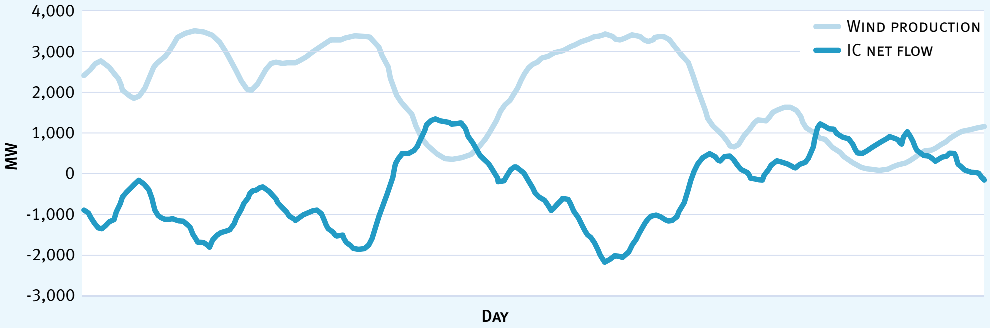
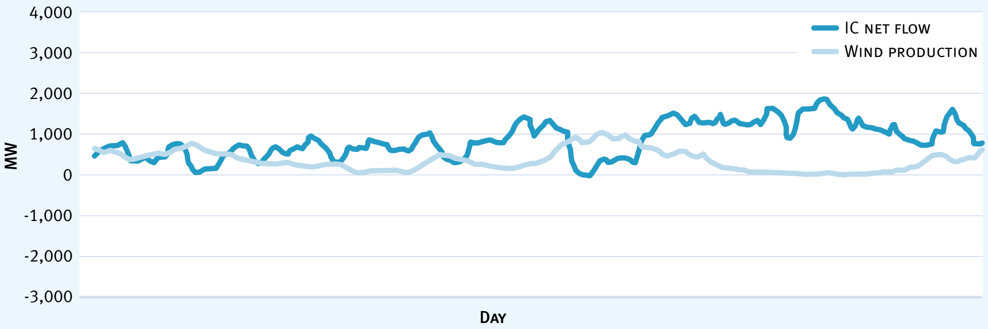
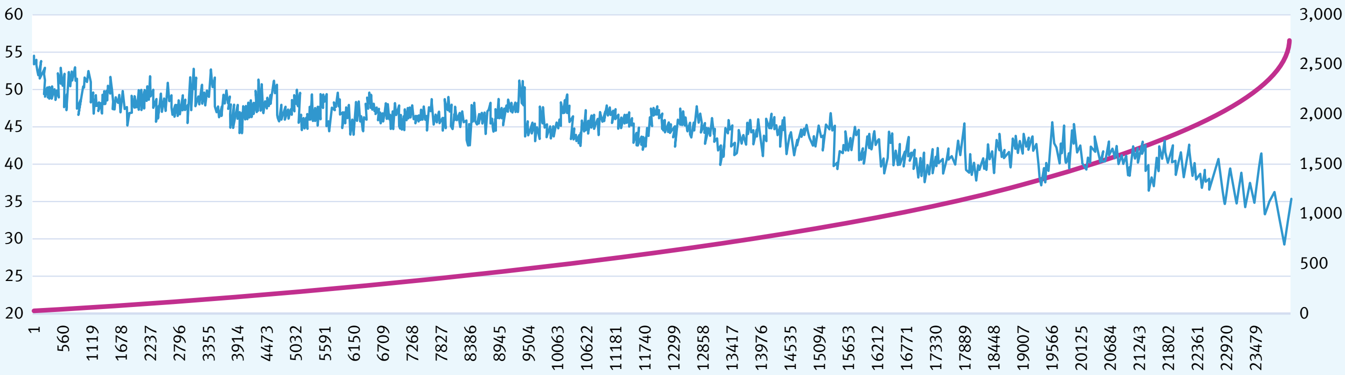


Figure 11: Wind generation in Denmark and interconnection patterns between Denmark, Norway and Sweden, 2-8 June 2011



Source: Energinet.dk

Figure 12: Correlation between wind generation and electricity spot prices in western Denmark between 1 January 2010 and 27 September 2012



Source: Energinet.dk, figure elaborated by Dong Energy

Figure 10 shows that when Denmark experiences sustained wind generation, the country exports power to Sweden and Norway. Conversely, when wind generation drops, the flow in the interconnectors is reversed and Denmark becomes an importing country. *Figure 11* reinforces the preceding conclusion by showing that the flow of electricity in the interconnectors is roughly constant when wind generation is constant too.

Another crucial effect of v-RES on the power system is the downward pressure they exercise on electricity spot prices (*Figure 12*).

The approximately 24,000 data points in *Figure 12* represent wind generation and electricity spot prices in western Denmark between January 2010 and September 2012.[10] The data points are arranged on the x-axis from the hours with the lowest wind generation to the hours with the highest wind generation.

The resulting picture is clear: the higher the generation from wind turbines, the lower the electricity spot prices.

However, the figure does not show the effect on the profitability of thermal power plants and their ability to cover their fixed costs as well as investment costs. But taken together with the drop in running hours for CCGTs, as shown earlier in *Figure 4*, it does make clear why conventional generators are experiencing the well-known 'missing money' situation. A cost-effective and technically sound integration of v-RES will need to also resolve this issue.

In conclusion, delivering on renewables will require adapting and developing the entire energy system. Managing increasing shares of v-RES calls for flexible and back-up generation capacity, integrated wholesale markets, storage, smart grids and demand-side participation, as well as adequate transmission and distribution infrastructure.

[10] To extrapolate trends which are easier to analyse, the price is calculated as a rolling average of 100 data points.

6

Trends in the Energy Community, 2008-2011

Six years ago the EU, wishing to create a framework for cooperation in the field of energy with its neighbours, established the Energy Community by signing a treaty with currently nine contracting parties: Albania, Bosnia and Herzegovina, Croatia, the Former Yugoslav Republic of Macedonia, Moldova, Montenegro, Serbia, Ukraine and UNMIK/Kosovo.[11]

The electricity markets in these countries vary widely: the Western Balkans and Moldova have small and fragmented electricity markets, which are mainly dependent on fossil fuels (coal, gas, oil). On the other hand, the Ukrainian electricity market alone is larger than those of the other Energy Community countries combined.

The region also has a fairly diverse set of economies, and while some suffered deep recessions in 2008-2009, others saw slow but positive economic growth.

In the face of large fiscal deficits, government expenditures have been under pressure in many countries of the region and economic growth is generally unpredictable. Pre-crisis regional economic growth averaged 5.5%, but after the recession and a second wave of economic slowdown recovery is expected to be quite slow with an expected average growth of only 0.5-1.5% in 2012.

Although the global economic downturn slowed the growth rate in electricity use during 2009, demand in 2010 returned to 276 TWh. Electricity consumption is still growing, albeit at a slower pace, so that in 2011 consumption amounted to nearly 282 TWh, representing a 2% increase compared to 2010. (source: Energy Community Secretariat, Annual Implementation Report 2012 (http://www.energy-community.org/pls/portal/docs/1770178.PDF).

Table 4: Evolution of Electricity Demand in selected countries, 2008-2011 (TWh)

Country	2008	2009	2010	2011
Bosnia-Herzegovina	12.2	11.6	12.3	12.6
Croatia	18.0	17.7	18.0	17.7
Serbia	33.8	33.3	34.1	34.4
Ukraine	184.6	168.5	183.4	187.0

Source: EURELECTRIC, Power Statistics (various editions) and Energy Community Secretariat, Annual Implementation Report 2012

[11] In line with UNSCR 1244.

According to the forecasts electricity demand for the Energy Community will grow by about 19% between 2010 and 2020, despite energy efficiency policies.

In 2011, the Western Balkans and Moldova had a total capacity of about 22 GW, of which Serbia accounted for about 33%, followed by Bosnia and Herzegovina with 22%, and Croatia with 18%. When adding Ukraine, the total capacity rises to 72 GW. In recent years the (very modest) increase of generation capacity, in addition to gas-fired plants, was primarily a result of rehabilitating existing power plants and commissioning several small-scale renewable projects. The available capacities consist of nearly 59% thermal, 19% nuclear and 22% of hydropower plants.

Regional composition of electricity generation has not changed much in recent years. Fossil fuels are the dominant source of electricity generation in the Western Balkans and Moldova, which rely mostly on coal (64%). Hydro and renewables account for about 36%. The Ukrainian electricity generation mix consists primarily of fossil fuels (48%), followed by nuclear (46%) and hydro and renewables (6%).

In 2010 electricity generation in the Energy Community exceeded 277 TWh (measured as net production injected into the system), mostly due to favourable weather conditions in the areas relying on hydropower plants. In 2011, net output of generation plants decreased to 273 TWh due to adverse hydrological conditions, with imports making up the difference needed to meet demand.

The region’s market reforms remain incomplete and at different levels among the Contracting Parties of the Energy Community. “The local markets are largely foreclosed by dominating incumbent companies and regulated generation and supply segments.”[12] As a result, the internal and regional electricity markets are not functioning properly and are not liquid enough to attract investors.

In view of the main Energy Community objectives, thinking beyond national borders must become the norm in this region as well. The Energy Community is preparing a Regional Energy Strategy with the aim of facilitating investments, promoting energy security and exploiting the regional cooperation potential.

The simultaneous need to meet the increasing level of energy demand and reduce the region’s carbon footprint requires new technological solutions, energy sector modernisation and further dialogue with neighbours.

Currently relatively low energy consumption per capita, high energy intensity in industry and large regional energy efficiency potential indicate that the region has a good growth potential.

The region’s strengths include inter alia: the large and diverse renewable energy potential; its position at the crossroads of Central Europe, South East Europe and the Middle East; comparatively low labour costs; low land or raw material prices; and rapid growth potential. All these factors demonstrate the region’s comparative advantage in electricity generation.

The major incumbent power utilities are still publicly owned in most of the countries, while decisions to invest are constrained by low returns, given the existing low prices and high cost of borrowed capital. As public borrowing capacity is limited, public-private partnerships could be one of the possible ways forward. This concept is already being promoted in some of the Contracting Parties.

[12] Energy Community Secretariat: Annual Implementation Report 2012.

7 VGB Analysis on availability and unavailability of power plants (2002-2011)

Because the performance indicators are important for analysing the behaviour of a power station, EURELECTRIC and VGB PowerTech decided some years ago to merge their data collection on the availability and unavailability of power plants into one single database.[13]

The creation of peer groups ensures that all data coming from different power plants can be evaluated according to similar technical characteristics, capacity ranges, fuels, etc.

To date, for all technologies, the database manages a power plant capacity of 256 GW representing 638 units in 13 European countries (AT, BE, CH, CZ, DE, ES, FI, FR, IE, IT, NL, PL, PT).

However, the partial data collection for each country and each technology by primary energy source does not allow reporting of performance indicators like the supply data in Chapter 3 on a country-by-country basis.

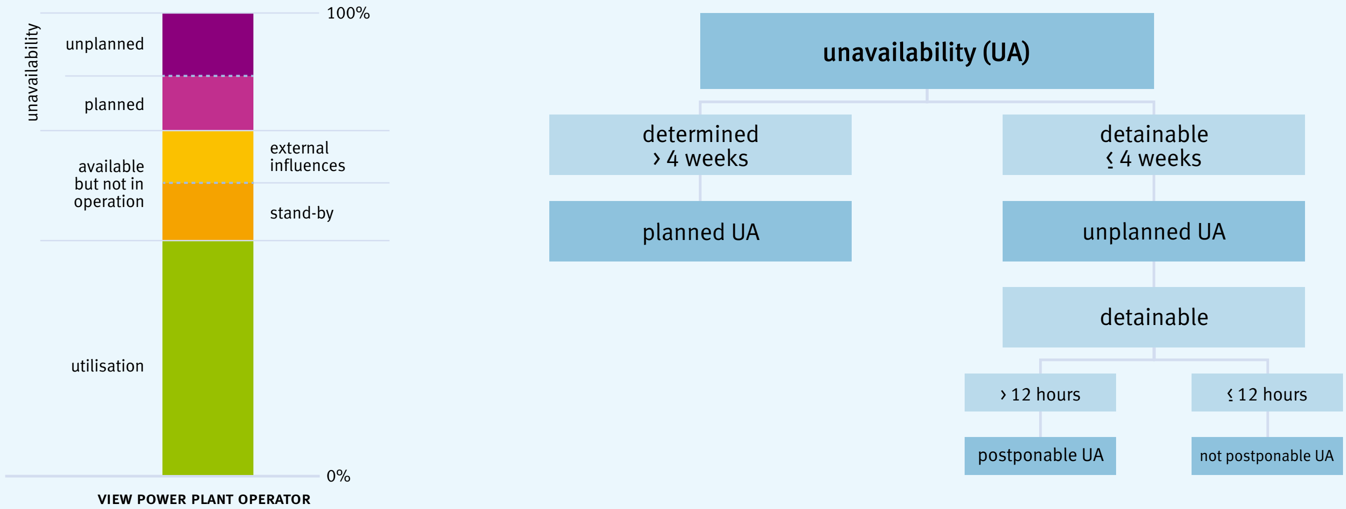
The presentation below covers global availability/unavailability results and analysis for fossil-fired power plants and nuclear power plant. This presentation is an abstract of two VGB technical-scientific reports: Availability of Thermal Power Plants 2002-2011 and *Analysis of Unavailability of Thermal Power Plants 2002-2011*.

[13] According to standardised uniform definitions and recording procedure (1), the data are collected in a database with the help of an adapted software tool called KISSY (Kraftwerk InformationS System, which translates into Power Plant Information System). KISSY also includes data on South Africa, which are not shown here.

Evaluation of the availability and the unavailability of power plants

Availability and Utilisation of fossil-fired units
Figure 13 shows the concept of availability and utilisation for an electricity producer and also explains the unavailability of a plant.[14] Availability and utilisation are perhaps the most important factors for explaining the behaviour of a plant as well as the operation mode within a plant or a fleet.

Figure 13: Definitions of availability and utilisation of power plants



Source: VGB PowerTech

[14] The exact definitions of availability and utilisation are explained in the document referenced (1).

The typical outcome of the standardised availability analysis is illustrated in *Figure 14*, which shows the yearly evolution, between 2002 and 2011, of different availability and utilisation indicators as well as the global values. The precise figures are reported in the table below. The sample of units taken into account represents a global capacity of 788.8 GW in AT, CZ, DE, FR, IT, NL, PL, PT.

Figure 14: Availability and unavailability indicators (EU countries AT, CZ, DE, FR, IT, NL, PL, PT)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	02-11
Number/Unit Years	237	239	247	249	249	252	250	239	244	248	2,454
Capacity (gross) (MW)	73,585	75,543	80,122	80,942	79,538	80,672	80,368	75,882	80,015	82,104	788,770
Time Availability (%)	83.3	87.7	87.0	86.8	86.8	85.9	84.2	83.3	83.5	83.4	85.7
Time Utilisation (%)	60.3	61.9	61.7	62.4	63.7	66.7	61.7	62.4	59.5	59.2	62.0
Energy Availability (%)	87.2	85.4	84.3	84.2	83.4	83.3	82.4	80.7	82.3	81.7	83.5
Energy Unavailability (%)	12.8	14.6	15.7	15.8	16.6	16.7	17.6	19.3	17.7	18.3	16.5
planned part (%)	7.2	6.9	8.0	8.7	9.3	8.7	9.5	10.4	10.6	9.7	8.9
unplanned part (%)	5.6	7.7	7.7	7.1	7.3	8.0	8.1	8.9	7.0	8.6	7.6
postponable (%)	1.0	1.1	1.2	1.4	1.6	1.3	1.4	2.1	1.5	1.7	1.4
not postponable (%)	4.6	6.7	6.57	5.7	5.7	6.7	6.7	6.8	5.6	7.0	6.2
Energy Utilisation (%)	51.0	53.1	52.7	53.2	52.9	55.2	51.0	51.8	50.3	49.4	52.1

Source: VGB PowerTech database

Unavailability analysis of thermal power plants

If we consider the availability of the fossil-fired power plants over the last three years (2009-2011), we note a small variation of the time and the energy availability at around 84% and 83% respectively.

On the other hand, the utilisation is lower than the availability (around 57% of energy utilisation over three years). The analysis of these figures over ten years shows the impact on the supply system of the increase of renewables and the required priority dispatch of renewables: utilisation of conventional plants has fallen. The decrease of annual operating hours for conventional plants leads to severe difficulties in covering the cost of generation and removes any incentive for the building of new thermal power capacities.

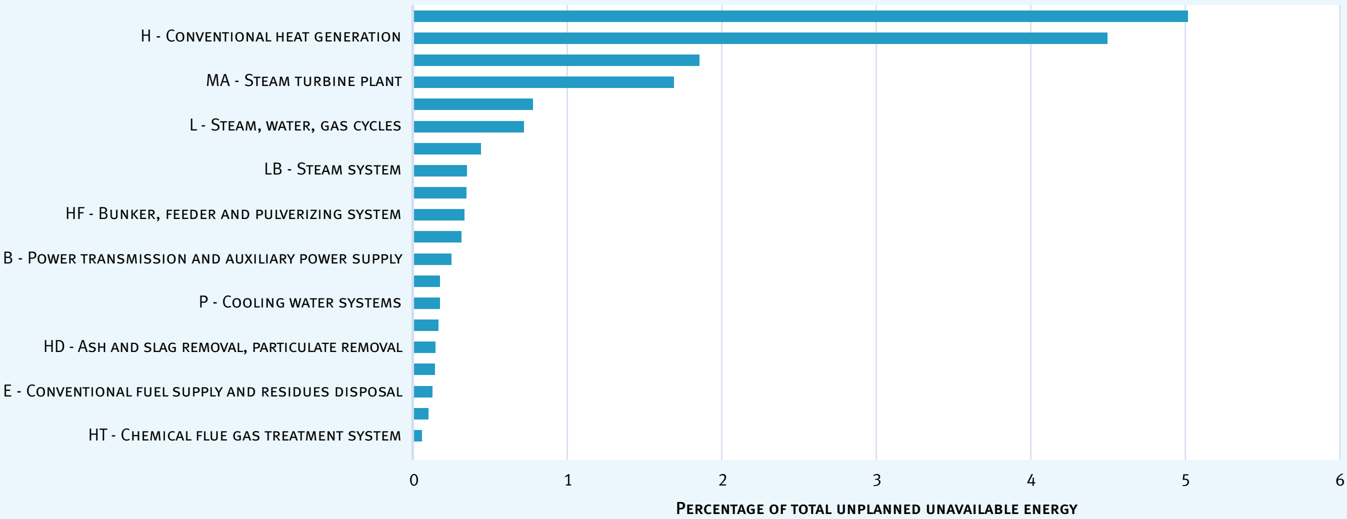
The planned and unplanned outages are excellent indicators of the technical status of each installation. The duration of a planned outage is determined by the level of repair work on damaged or aged components as well as the retro-fit measures taken to upgrade the plant performance. Unplanned outages, which can be further divided into postponable and not-postponable outages, illustrate the real operation of the plant and/or its components. The ratio of planned to unplanned outages indicates the quality of the maintenance work undertaken to avoid any damage during plant operation. Furthermore, the possibility to postpone an unplanned unavailability in times of ever increasing v-RES generation is an indicator of the stability of the system.

Events which caused unavailability are analysed in the annual VGB report *Analysis of Unavailability of Thermal Power Plants*. The relevant data are collected online by member companies on an annual basis. Because not all member companies participate in this complex recording, using the KKS and EMS codifications for describing and evaluating the event characteristics, the unavailability analysis is based on different plant collectives. In the latest reporting period (2002-2011), a total of 97,867 events from 259 generation units were evaluated.

Information on the main components and systems affected by the unplanned unavailability is important in order to adapt any maintenance programme to the most efficient operation policy.

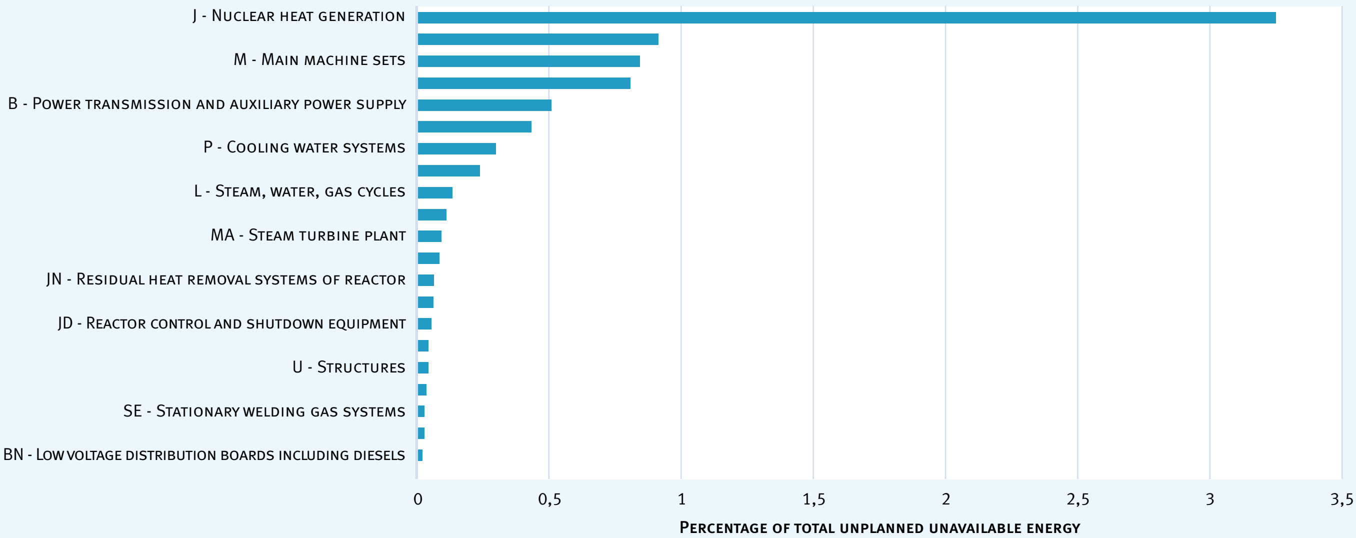
Figures 15 and *16* show the main components causing the most unplanned unavailability for fossil-fired power plants (170 units in AT, DE, IT, NL, PT) and nuclear power plants (23 units in DE, CH) respectively, between 2002 and 2011. They show that most of the unplanned unavailability is caused by the heat generation itself. It can also be due to suspicion of failure on a reactor safety component, which prompts the immediate shutdown of the nuclear unit. The generator itself causes around 1% of the total unplanned unavailability for all thermal power stations.

Figure 15: Components causing unplanned unavailability of fossil fired units (2002 - 2011)



Source: VGB PowerTech database

Figure 16: Components causing unplanned unavailability of nuclear units (2002 - 2011)



Source: VGB PowerTech database

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