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ELECTRICITY FOR EUROPE

Power Statistics & Trends 2011

SYNOPSIS

VGB POWERTECH

SPECIAL ISSUE: VGB CONTRIBUTION ON AVAILABILITY/UNAVAILABILITY OF POWER PLANTS

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 2011

Power Statistics & Trends 2011

SYNOPSIS

9 Key Messages

1. Demand recovers

In 2010, electricity demand recovered in the EU-27, reaching 2008 – and thus pre-recession – levels (*Figure 1*). However, the recovery did not occur uniformly across Europe. In Germany and Spain, for instance, electricity demand increased compared to 2009 (by 5% and 3% respectively), but did not yet reach 2008 levels. In other cases demand rose to above pre-recession levels (Belgium saw a 11% increase over 2008). The trend of increasing electrification continues.

2. Capacity increases

The EU's total installed capacity continued to grow in 2010, reaching 870 GW – an increase of 28 GW, or 3% (*Table 3 & Figure 5*). Renewables other than hydro accounted for the fastest growing sources, with over 22 GW being connected to the grid; this accounts for more than three quarters of the newly installed capacity. As for nuclear capacity, about 2 GW were withdrawn from the grids, notably due to the closure of the Ignalina power plant in Lithuania. Fossil-fired capacity also grew, although only marginally, by 1.8%.

3. Generation grows

All power generation technologies contributed to the increase in electricity generation. Renewables made up the lion's share, sustained by good performance of hydro in southern Europe, due to favourable weather conditions in the reference period, and an increase of installed capacity for wind, solar and biomass. Hydro generation grew by 7%, other renewable energy sources (RES) generation by 14% compared to 2009 levels. Fossil-fired generation saw an increase of 5%, particularly in gas. The nuclear increase was smallest in comparison, with 1% above 2009 levels (*Table 4 & Figure 4*).

4. Variability increases

Data shows the increasing share of variable generation technologies in the power mix: wind increased from 74,614 MW to 83,819 MW between 2009 and 2010, and solar PV from 15,244 MW to 22,981 MW in the same period (*Table 3*). Forecasts for future growth are even more spectacular, as *Figure 6* demonstrates. The gap between capacity and generation is therefore expanding, requiring ever more back-up capacity. This will be especially true up to 2020, since alternative and complementary means such as large-scale storage or demand-side measures are unlikely to deliver beforehand.

5. Technologies: Use them all!

Power was and will be generated using all available technologies. *Power Statistics & Trends 2011* shows that the entire range of power generation technologies has been used, although the proportions have shifted over time. This diversified mix is crucial to ensure security of supply and to achieve an optimal balance between variable RES and flexible and back-up capacity (*Figure 4* & *Table 4*).

6. The electricity industry has invested significantly in RES capacity

The electricity industry has taken on the challenge and has become a significant investor in 'new' RES (mainly wind, solar and biomass). With 276,666 MW in 2010, its capacity has nearly doubled since 2000 (*Figure 6*). But for the industry to deliver in an optimal way – carbon-neutral, commercially viable, at affordable prices – a system approach has to be applied, developing both RES and back-up within an integrated European electricity market, which is yet to be set up.

7. New conventional capacity is required

There is an important need to replace ageing power plants in Europe in the next years. The Large Combustion Plant Directive, as well as the Industrial Emissions Directive will take many older plants out of the system within the next decade. *Power Statistics & Trends 2011* reveals that the needed installation of new capacity is not taking place, apart from a limited switch to gas and a massive introduction of renewables as a result of generous support schemes. Incentives for setting up conventional capacity are lacking, and limited operation hours affect business cases just as negatively as regulatory uncertainty and insufficient remuneration (*Figure 5* and *Table 3*).

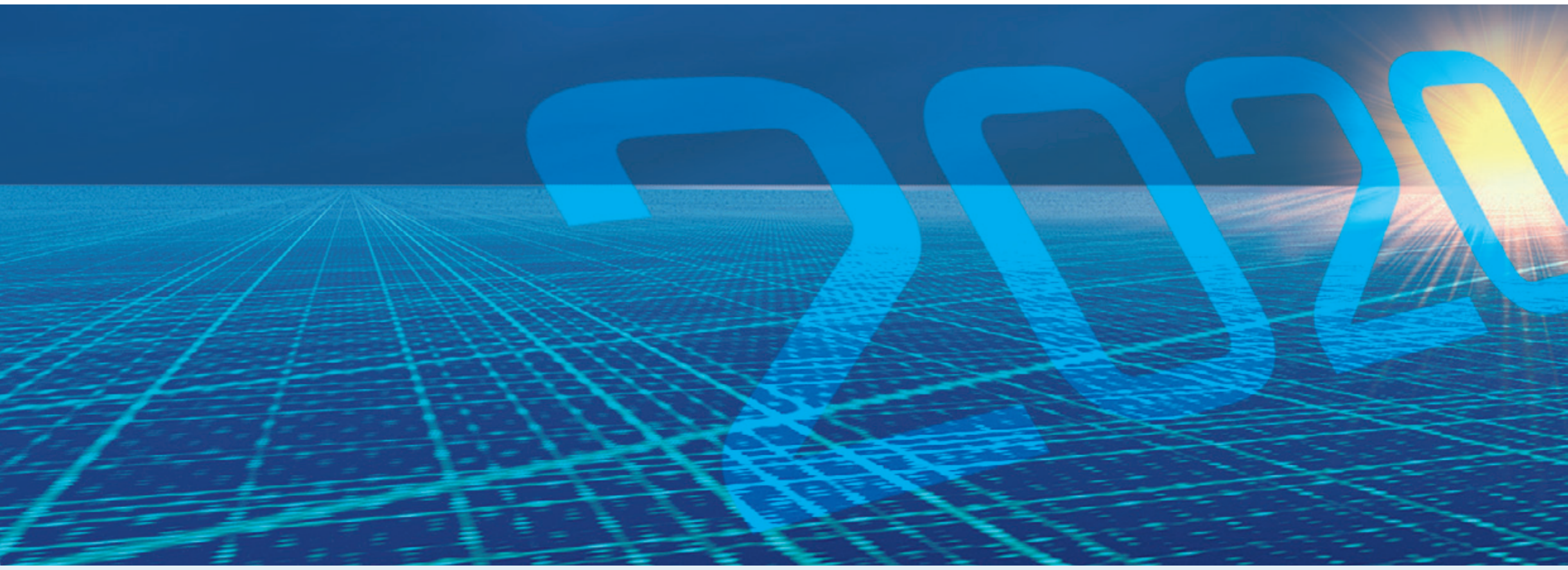
8. Total CO_2 emissions decrease, but specific emissions increase slightly[1]

As a result of decreased electricity generation between 2008 and 2009, the power sector's CO_2 emissions fell further in 2009, from 1,186 GT CO_2 to 1,127 GT CO_2. However, the carbon intensity of the electricity industry – measured in grams of CO_2 emitted per each kWh of electricity generated – increased slightly, from 368.4 g/kWh in 2008 to 369.7 g/kWh in 2009. A possible explanation could be the increasingly flexible operation of the fossil-fired fleet enforced by the deployment of variable RES. Faced with more frequent starts and stops as well as more frequent part-load operations, thermal power plants become less efficient and emit more CO_2.

9. Conventional plants are less available – despite more maintenance

Availability of conventional power plants has deteriorated despite increased maintenance efforts. The analysis in this year's special issue "availability/unavailability of conventional power plants" (pages 14-20) shows that the forced outage rate has increased over the last ten years even though maintenance has increased as well. The higher damage rate and maintenance needs can possibly be linked to the more flexible operation mode (i.e. part-loading) of the conventional fleet. Moreover, the EU power fleet is ageing: more than 70% of the conventional power fleet is older than 30 years. The economic viability of conventional generation is severely constrained by the lack of revenues for existing plants and the lack of incentives for replacing them.

[1] Emissions data in this section refer to 2009 as 2010 data were not yet available for some countries. It is likely that overall CO_2 emissions in 2010 will be slightly higher than in 2009 because of increased electricity generation driven by demand recovery. The development of carbon intensity in 2010 is less clear: the substantial increase in RES generation between 2009 and 2010 might have driven down carbon intensity, but has probably also increased part-loading operation of fossil-fired plants, hence re-balancing carbon intensity. Source: EURELECTRIC, based on *Power Statistics & Trends 2011* and European Environmental Agency (EEA).



What is *Power Statistics & Trends 2011*?

Power Statistics & Trends 2011 gathers the latest available data from the European electricity sector, including forecasts for up to 2030.

It contains data:

- from EURELECTRIC members from all 27 EU member states, as well as Switzerland, Norway and Turkey. For the first time, we also gathered data from Energy Community members, and held a workshop with the organisation in Vienna, in February 2011. We are pleased to present data for Croatia, Bosnia-Herzegovina, Serbia as well as for Ukraine, and intend to complete the data collection for the other states of the region in the coming years;
- for the years 1980, 1990, 2000, 2008, 2009, as well as forecasts for 2020 and 2030.

concerning:

- the structure of the electricity industry;
- trends in general economic indicators;
- peak demand and load management;
- medium and long-term generating prospects;
- sectoral electricity consumption;
- electricity balances;
- fuel consumption in and emissions from the electricity sector;
- availability of power plants in Europe, data provided by EURELECTRIC's partner VGB.

Power Statistics & Trends 2011 also contains preliminary data for 2010.

This synopsis contains key messages about the electricity industry and its position in Europe. It includes a special issue from EURELECTRIC's partner VGB on the availability/unavailability of power plants.

Setting the Scene: Macroeconomic and Regulatory Trends

Recovery of electricity demand to pre-crisis level

In 2010 the European electricity sector recovered from the severe impact of the economic recession on electricity demand. While total energy demand decreased by 4% between 2008 and 2009, the sector saw a catch-up to pre-crisis demand levels in 2010. However, the recovery was not uniform across Europe. In Germany, Spain and Bulgaria, for instance, electricity demand significantly increased compared to 2009 (by 5%, 3% and 2% respectively) but did not yet reach 2008 levels. In other cases, demand increased far beyond pre-recession levels (Belgium saw a 11% increase over 2008). In several countries demand continued to decline between 2009 and 2010, with Romania accounting for the biggest decrease (-8%), followed by both Estonia and Malta (both -4.5%).

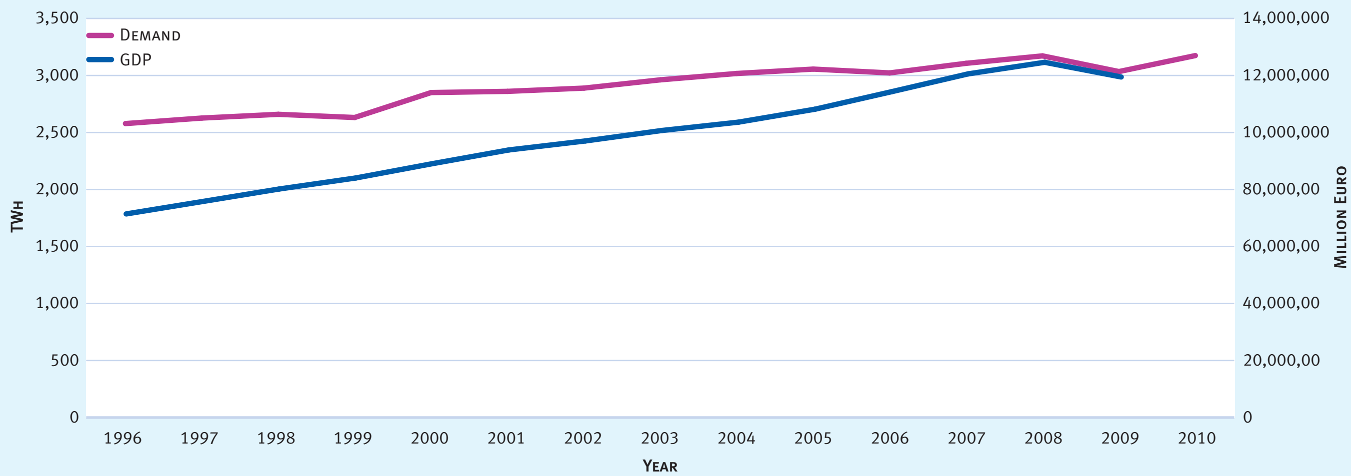
Gross domestic product trends

Although economic growth resumed in 2010, the recession will have a long-term impact even beyond 2015. It will be difficult to recover the important losses in gross domestic product (GDP) across Europe in the near future, and the deep crises in several EU member states have become an existential threat to the euro-zone itself.

According to Eurostat, GDP growth was negative in 2009, with -4.3% in the EU-27, falling by nearly five points from 0.5% in 2008. It recovered to 1.9% in 2009, and average EU growth prospects for 2011 and 2012 are indicated to be around 1%. The inflation hit 3.3% in EU-27 average, in October 2011.[2] *Figure 1* highlights the parallel evolution of electricity demand and GDP, and reflects the severe impact of the recession on both. It also demonstrates that energy intensity has decreased, i.e. less electricity is needed for an increase in GDP.

The standard of living in Europe (GDP per capita) is expected to increase at a very low rate of roughly 1-2% annually, near or even above inflation rates. Recovery will be very unequal across Europe, although forecasts are contradictory and require further detailed analysis. The higher pressure on all resource requirements and infrastructure, including energy, electricity and associated networks, means that strong incentives for investment will be needed.

Figure 1: EU-27 Total electricity demand (TWh) and GDP growth (1996-2009)



Source: EURELECTRIC (Electricity demand) / Eurostat (GDP data)

[2] Data from Eurostat 2011. http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsieb020

TABLE 1: EU-27 TOTAL ELECTRICITY DEMAND (TWH)

EU 27	1990	2000	2008	2009	2010	2020
Total Electricity Demand	2,344.2	2,845.5	3,167.6	3,029.8	3,170.2	3,466.8

Source: EURELECTRIC

DEMOGRAPHY: LOW POPULATION GROWTH TO BE OFFSET BY DYNAMIC MIGRATION

Demographic trends in the EU-27 will continue to follow a low growth scenario (*Table 2*), with some countries on a negative growth track. For instance, the German population will drop from 82 million in 2008 to 78 million in 2030, while Italy's population of approximately 60 million is expected to decrease to 58 million during the same period. Dynamic immigration is expected to be an important factor in offsetting this trend.

TABLE 2: DEMOGRAPHIC EVOLUTION OF THE EU POPULATION (THOUSANDS, AT YEAR END)

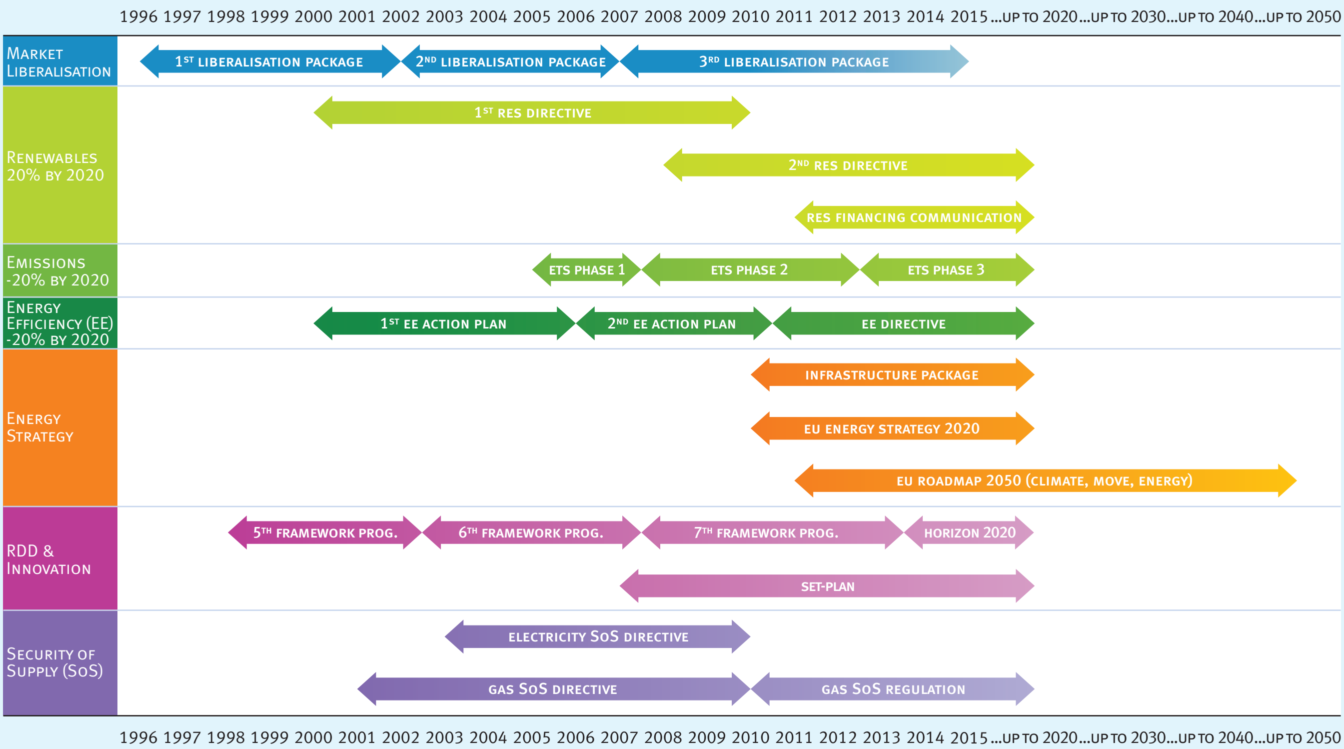
EU 27	1980	1990	2000	2007	2008	2009	2010	2020	2030
Population	463,648	476,199	488,145	495,291	497,686	499,705	501,125	515,125	521,653

Source: Eurostat 2011

POLICY AND REGULATORY TRENDS IN 2011: ENERGY EFFICIENCY, ROADMAPS, INFRASTRUCTURE...

The following figure provides an overview of the main EU energy policy trends in the long, medium and short term.

FIGURE 2: EU LEGISLATIVE FRAMEWORK



Overall energy policy: targets and roadmaps

The European Union has set ambitious energy and climate policy targets for 2020. These targets require significant efforts from the electricity industry. As an example, the 20% overall target for renewables would require about 35% RES in electricity generation, more than doubling its share. In addition, new opportunities in the form of plug-in, fully electric vehicles in road transport are planned to bring about the 10% target for renewable energies in transport. In 2010, member states had to submit National Renewable Energy Action Plans, outlining how they would reach their national targets under the overall 20% goal.

In 2011, the European Commission (EC) published a number of texts looking at energy policy perspectives. In early 2011, it presented the EU Energy Strategy 2020, in order to bring the overall energy policy in line with the 20-20-20 set of targets for 2020. In addition, three roadmaps for 2050 have been presented or are foreseen. A "Roadmap for moving to a competitive low-carbon economy" was delivered in March, and a White Paper on transport published shortly thereafter. A detailed Energy Roadmap will follow suit on 13 December 2011, featuring five decarbonisation scenarios: a high energy efficiency scenario, a diversified supply technologies scenario, a high renewable energy sources scenario, a delayed carbon capture and storage (CCS) scenario and a low nuclear scenario. They are compared against a reference and a current policy scenario. All of them foresee that electricity will have to play a much greater role than now, almost doubling its share in final energy consumption from current levels to 36-39% in 2050. There is also convergence on the co-existence of centralised and decentralised power systems and heat generation including their increased interaction, on the need for very significant energy consumption reductions (energy demand drops between 32 to 41% in 2050), and on the substantial rise of renewables to at least 55% in 2050, compared to 10% today.

The third package: implementation started

The Third Energy Package came into force on 3 March 2011. Progress has been made – ahead of this deadline – in the drafting of the network codes for both electricity and gas markets. Against this background, the overall compliance of national legislation with the Second and Third Energy Package remains moderate and a number of infringement procedures have been initiated by the European Commission to improve the implementation of these acts into national law. Notwithstanding this, the Heads of State and Governments of the European Union reiterated at their 4 February summit the urgency of completing the internal market in electricity and gas by no later than 2014 and stressed the role of reinforced grids in underpinning robust and competitive energy markets.

Legislative trends on power generation technologies

Renewables

The EC Renewables Directive passed into legislation in April 2009. The directive sets the EU 20% renewables target, an incremental increase of just over 11 percentage points on the 2005 baseline percentage of 8.5% (9.2% in 2006). The 20% target is based not on generation, but on a percentage of final energy consumption. It is shared among member states on the basis of an incremental increase of 5.5 percentage points on the 2005 figure for all member states, plus an additional incremental increase, modulated according to the member states' GDP per capita (with some account also taken of existing progress in developing renewables in the country).

In November 2011 EURELECTRIC published the results of RESAP, an extensive programme of work on renewables showing the pathway to the 2020 targets and which further policy measures will be needed to achieve these very challenging targets.

Fossil fuels: more focus on CCS

Following the nuclear accident in Fukushima and subsequent radical decisions on nuclear energy in some countries, the important role of fossil fuels has become even more evident. Gas, and to a lesser extent coal, are more prominent in today's political discussions. Gas provides flexibility in generation – therefore complementing renewables. In addition, gas faces little public opposition and can be stored more easily than electricity, thus serving as upfront energy storage to electricity.

Fossil fuels will continue to play an important role in the European electricity production for some decades to come, provided their CO_2 emissions can be significantly reduced. The most promising technology is CCS, or alternatively CO_2 use (CCU), which has yet to be applied to electricity generation on a large scale and needs to be demonstrated by integrating all different segments. European policymakers have given political support for a demonstration programme of industrial-scale integrated CCS demonstration plants by 2015. However, the financial risks of such a large-scale demonstration programme cannot be borne by the industry alone. It is also important to stress that CCS suffers from a lack of public acceptance in several countries.

As for financing, in the broader framework of the Economic Recovery Plan, the European Energy Programme for Recovery (EEPR) established funding for six projects, which will demonstrate all three types of capture technology (i.e. post-combustion, pre-combustion and oxy-fuelling) as well as two different storage options (i.e. depleted hydrocarbon fields and saline aquifers).

Moreover, the Commission put forward a proposal on how to finance a European demonstration programme in the framework of the EU-ETS "New Entrants' Reserve" funding scheme (NER300). After difficult negotiations the decision was eventually reached through comitology in February 2010 and the first call for proposals is currently underway. In February, project developers applied to the member states in which projects are planned. Member states then made a preliminary choice of the projects they intend to co-finance and transmitted those selected (13 projects for the CCS category) to the European Investment Bank (EIB) for the due diligence assessment, which should be completed by February 2012. The list of projects will then be passed back to the Commission, which, after a new round of consultation with member states, will issue a final decision by the end of 2012.

Nuclear

After the nuclear accident in Fukushima in March 2011, the continued use of nuclear energy in the EU gained prominence in the political and public discussion. Decisions vary widely among member states, ranging from maintaining or even expanding nuclear programmes – as in Slovakia, the UK and France – to the phase-out of existing nuclear reactors and/or stopping new building, like in Germany, Switzerland or Italy. In March 2011, EU energy ministers agreed to develop stress tests for EU nuclear power plants. Results will be presented in December 2011. EURELECTRIC has supported this greater European approach from the very beginning, considering that a European energy policy without a common nuclear safety policy does not make sense.

The EU has also adopted a directive on the management of radioactive waste management and spent fuel, presented in 2011. The new law sets standards for waste management which all member states would have to follow. A first proposal for banning exports of nuclear waste to third countries has been rejected by the Council.

Security of supply and infrastructure development

Security of supply is an issue in power generation with gas. Since the importance of gas to power is widely expected to increase, security of supply is likely to matter more in power generation, albeit indirectly. With security of electricity supply strongly network related, more attention has to be paid to infrastructure, as well as to development plans such as the ENTSO-E Ten Year Network Development Plan (TYNDP).

In November 2010, the European Commission published a communication on energy infrastructure priorities, in which it outlined its proposal for a new methodology to address the energy infrastructure challenges on the European level. This proposal included:

1) identification of the energy infrastructure priority projects, with corridors/areas that should ideally lead to interconnecting networks at continental level;
2) development of a common methodology to improve regional cooperation between member states and regulators, leading to cross-border cost allocation rules and new financial instruments to facilitate their implementation;
3) development of a streamlined permitting regime for infrastructure projects;
4) provision of public spending on projects showing a sound cost-benefit analysis but that will not be taken up by the market alone.

Following overwhelming support for the communication from the European Council in February 2011, the European Commission adopted, on 19 October 2011, a plan to spend 9.1bn euro on energy infrastructure in the framework of the so-called 'Connecting Europe Facility', as well as a regulation outlining guidelines for trans-European energy infrastructure.

The sharp decline in gas prices in 2010, due to the economic crisis as well as the shale gas boom in the United States market, induced oversupply on the European market and had a beneficial effect on the security of supply. The last gas crisis in Europe in January 2009, arising from a two-week interruption of Russian gas flow through Ukraine, had led to the adoption of a regulation on gas security of supply (994/2010). It obliged all member states to take effective action in advance, set up reverse flows and introduced solidarity on a regional, rather than a European level. The regulation also introduced the concept of 'infrastructure standard', with a view to mitigating member states' dependence on single or limited gas infrastructure. The EC gas coordination group, in which EURELECTRIC participates, continues to monitor potential supply crises, currently particularly due to recent events in the MENA (Middle East and North Africa) region.

External energy policy

With the Strategic Energy Review, the European Commission started regular reports on European energy policy in 2007. The bi-annual report takes stock of recent developments in energy policy and energy-related geopolitics, and prepares the ground for policy proposals. On 7 September 2011, the Commission published an external energy policy communication elaborating on the strategic partnership with Russia, the MENA region's importance and the Southern Corridor, among others. In its own policy paper, entitled "One Voice in One European Market", EURELECTRIC argues that common positions in external energy policy will be the natural result of a true European energy market.

Electricity Statistics

Generation Trends

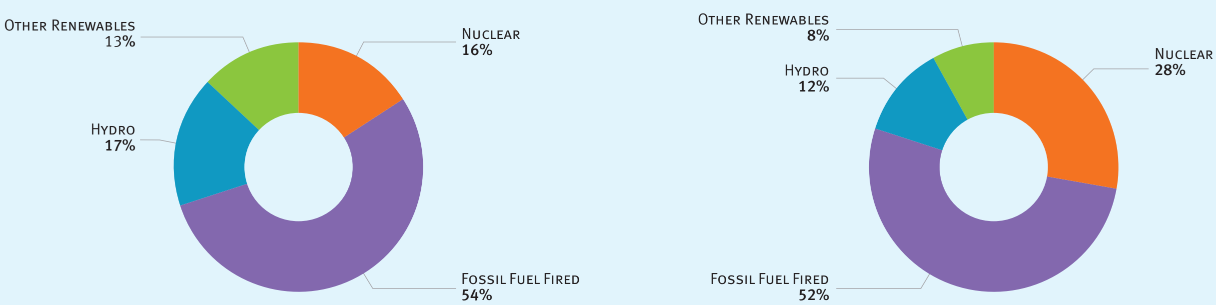
Installed capacity vs. electricity generation: independent trends

Figure 3 shows the importance of the capacity factor of generating capacities. Different power generation sources have different capacity factors, which are influenced by the type of resource used, the technology, etc.[3] Therefore, the shares of installed capacity for different technologies do not necessarily translate into the same shares in electricity production.

Thus, although nuclear represented roughly one sixth of total generating capacity in 2009, its actual share of electricity production was almost one third, since nuclear power plants are commonly run in base-load mode. By contrast, hydro capacities in the EU-27, which represented a similar share of generating capacity, yielded lower values of electricity production due to the several different running modes of hydro power plants. The low capacity factor of wind and solar (grouped under ‘other renewables’ in *Figure 3*) translates into relatively low electricity generation figures compared to installed capacity. However, this discrepancy does not apply to biomass plants, which tend to run in base-load or mid-merit mode. It is worth noticing that whilst the installed capacity of renewables increased by 17 GW (or 17%) in 2009, the actual generation increased by only 10% to 249 TWh (up by some 20 TWh from 2008). This is due to particularly poor wind conditions in 2009.

Figure 3: Installed capacity vs. electricity generation in 2009 in the EU-27

Installed Capacity EU-27 – 2009 | **Electricity Generation EU-27 – 2009**



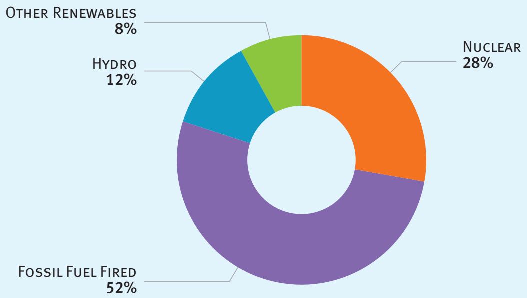
[3] The capacity factor of a power plant is the ratio of the actual electricity produced in a given period to the hypothetical maximum possible, i.e. its output if it had continuously operated at full nameplate capacity.

A new, less carbon-intensive mix emerges – but is put into question by nuclear phase-outs

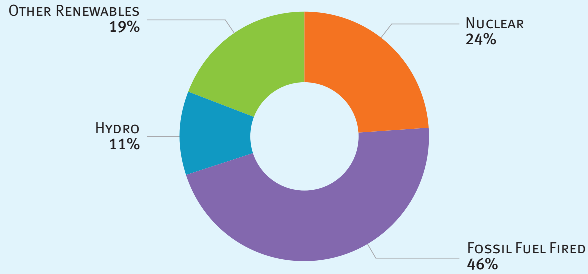
According to the assumptions by EURELECTRIC members (*Figure 4*), low-carbon generation sources such as RES, hydro and nuclear, will constitute the major generation source by 2020, delivering about 2,000 TWh, compared to about 1,700 TWh from fossil fuels, the share of which decreases from 52% in 2009 to 46% in 2020. Low-carbon generation sources will continue to dominate the generation mix thereafter.

Figure 4: Evolution of electricity generation in the EU-27 in 2009 and 2020

Electricity Generation EU-27 – 2009



Electricity Generation EU-27 – 2020



Capacity by technology: use them all

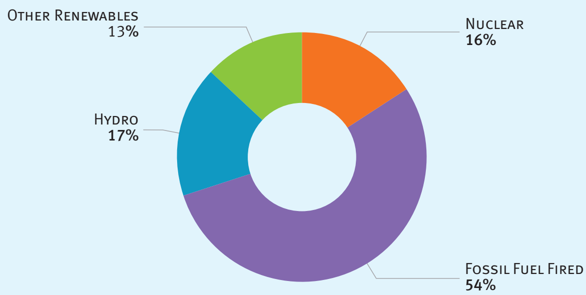
A closer look at generation capacity by technology clearly demonstrates that the European electricity mix builds on a wide variety of energy sources and is set to remain highly diversified (*Figure 5*). The balance between low-carbon and fossil-fired generation will reverse by 2020, with the latter shrinking by 13 percentage points to 41%.

Nuclear trends after Fukushima

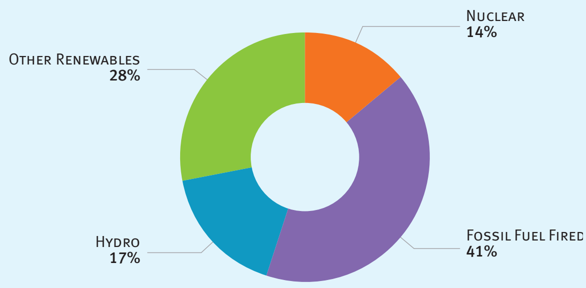
The European Union's nuclear park comprises 143 power plants (NPPs); 28 of them are more than 30 years old. The nuclear capacity increase in the reference period 2009-2010 was rather limited, about 1%. At the same time, 2 GW were taken out of the system.

Figure 5: Evolution of installed capacity in the EU-27 in 2009 and 2020

Installed Capacity EU-27 – 2009



Installed Capacity EU-27 – 2020



Fossil fuel capacities remain stable; the share of gas increases

Natural gas has been displacing oil and coal in the last decade, creating the so-called *'dash-for-gas'*. Thanks to the lower carbon content of the primary fuel, shorter construction lead-times and lower capital costs, a major deployment of combined cycle gas turbine plants (CCGTs) has been witnessed throughout the continent, with capacity of gas-dependent electricity increasing massively from 118,432 MW in 2000 to 189,167 in 2009.[4] Natural gas is assumed to further increase in the upcoming decades, as nuclear capacities are to be phased out in countries like Germany. As back-up capacity, it will play a fundamental role in flexibly complementing the integration of variable renewables generation into the EU electricity markets.

The installed capacity of oil-fired power plant decreased from 70,494 MW to 55,593 MW between 2000 and 2010.[5] Oil-fired generating units are still used for peaking purposes, i.e. in times of high electricity demand. Furthermore, some countries, especially small island systems such as Malta, Cyprus and many non-interconnected islands of Greece still rely on oil to generate their electricity, although a shift towards gas is envisaged.

Altogether, the share of coal-based capacity has remained nearly stable between 2000 and 2009, with a minor decrease from 206,630 to 201,561 MW.[6]

There is no doubt that carbon capture and storage (CCS) will influence the future use of coal and gas in the generation mix, provided the technology reaches maturity and commercial roll-out starts in the period 2020-2025.

New installed capacity: RES dominates, followed by gas

As shown in *Figure 6* and *Table 3*, some 28 GW of new capacity have been added between 2009 and 2010, of which three quarters was RES. In conventional power generation, gas remains the fastest growing technology.

With regards to nuclear, this year's statistics do not reflect the German phase-out, but only the decommissioning of the Ignalina nuclear power plant, which explains the slight decrease of some 2 GW between 2009 and 2010.

RES capacity takes off

The advent of new RES, with hydro retaining an important share, is confirmed as a major trend. Between 1980 and 2010, RES capacity (mainly wind, solar and biomass) increased more than 80 times from about 1.6 GW to more than 134 GW. This trend is forecast to continue up to 2020, when RES generation capacity will have reached 264 GW (*Table 3*).

As the major renewable energy source in the EU-27, hydropower accounted for roughly 142 GW of installed capacity in 2010. Although hydropower capacity is projected to only marginally increase by 2020, its role will remain crucial: in certain EU areas it will provide the primary back-up for variable renewable generation such as wind and solar power.

Table 3 below highlights the trends, which place hydro as the main renewable source on top of the list, in terms of capacity. By 2020, on- and offshore wind will have taken the lead. Solar PV as well as biomass show impressive development trajectories. The significant share of variable RES – wind and solar – and to a lesser extent hydro, is evident.

Table 3: Generation capacity in the EU-27 (MW) in 2010 compared to 2008 and 2009

EU 27	2000	2008	2009	2010	2009/2008	2010/2009	2020
Nuclear	136,847	132,842	132,861	130,538	19	-2,323	127,496
Fossil Fuel Fired	391,306	445,428	454,155	462,173	8,727	8,018	382,074
Hydro	135,626	141,694	142,905	142,726	1,211	-179	160,974
Other Renewables	21,942	94,748	111,561	133,940	16,812	22,379	264,297
of which Solar	82	10,102	15,244	22,981	5,142	7,738	55,735
Wind	12,808	64,034	74,614	83,819	10,581	9,204	177,809
Biomass	3,940	9,852	10,019	10,071	167	52	17,086
Biogas	975	3,799	3,092	3,891	-707	799	5,795
Not Specified	440	1,198	1,143	1,144	-55	1	1,162
Total Installed Capacity	686,161	815,910	842,624	870,521	26,714	27,896	936,004

Source: EURELECTRIC

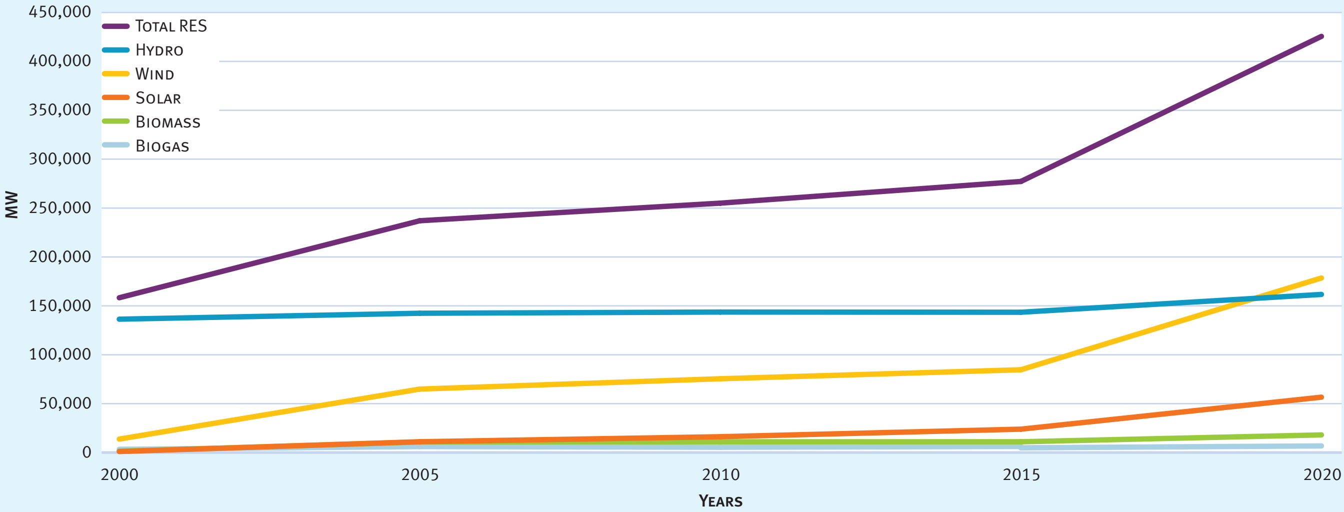
Note: Regarding the table above, it must be noted that whereas the aggregated figures for type of primary energy used are fairly complete, the breakdowns into RES subtypes might not always take into consideration all EU-27 countries. Nonetheless, the figures still provide some good hints on the latest developments of generating capacity and on expected future developments.

[4] Source: EURELECTRIC, based on GlobalData, Power E-Track.

[5] Source: EURELECTRIC, based on GlobalData, Power E-Track.

[6] Source: EURELECTRIC, based on GlobalData, Power E-Track.

Figure 6: RES generation capacity in the EU 27 (MW) present and future trends



Source: EURELECTRIC

Table 4: Generation in the EU-27 in 2010 compared to 2008 and 2009 (TWh)

EU 27	2008	2009	2010	2009/2008	2010/2009
Nuclear	891.0	849.8	858.2	-41.2	8.5
Fossil Fuel Fired	1,744.8	1,605.9	1,687.4	-138.9	81.5
Hydro	353.6	353.6	380.7	-0.0	27.1
Other Renewables	226.2	248.8	285.2	22.7	36.4
of which Wind	117.7	130.6	147.9	12.9	17.3
Not Specified	4.6	2.2	28.9	-2.4	26.7
Total Generation	3,220.2	3,060.3	3,240.4	-159.9	180.1

Source: EURELECTRIC

Power balances and the need for a single European electricity market

Increasing foreseeable unavailable capacity, the need for generation investment and for a balanced generation portfolio

A look at capacity balances across the EU reveals an increase in total foreseeable unavailable capacity in nearly all EU member states.

There are two reasons for this trend: on the one hand, the ageing generation park and related maintenance requirements are responsible for the current slight increase in foreseeable unavailable capacity. There is an urgent need to get investment conditions right to renew the generation park in many European countries, and to cope with the consequences of Directive 2010/75/EU on Industrial Emissions. Many old fossil fuel fired plants in Europe (especially coal, lignite and oil fired plants) will not be able to comply with the above mentioned directive and will have to be shut down, creating the urgent need for replacement capacity especially after 2020.

On the other hand, the non-dispatchable character of variable RES will accentuate this trend in the future. This fact underlines the need to improve the interaction between different generation sources, as well as the need to use them all in order to offset variability with non-variable conventional sources.

The economic crisis and the parallel temporary decline in power demand, as well as the ongoing base load to load-following shift have weakened business cases for new build. New projects in conventional generation have been delayed or written off across the EU, amounting to 27 GW of new capacity being delayed in the EU-27 plus Norway and Switzerland. Technical problems, like T 24, but also public resistance and lengthy permitting procedures account for additional delays.

Special Issue/Guest Contribution:
VGB analysis on Availability/Unavailability of Power Plants 2001-2010

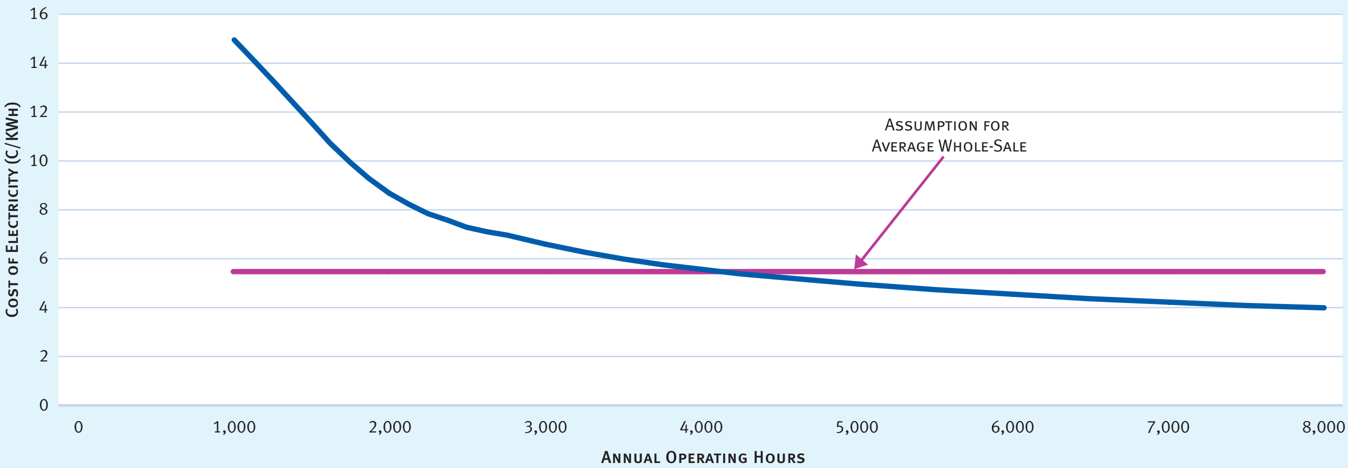
Introduction

Conventional power plants today have to deliver back up capacity for an increasing share of variable renewables, while continuing to ensure the lion's share of baseload. Data on the operational performance of conventional power plants are therefore increasingly important.

The plant operation data described here covers as many units as possible of Europe's power plant fleet, i.e. nuclear, fossil, and RES including hydro. The data set consists of operation records on the availability and unavailability figures for individual power plant units; the unavailability data are divided into planned unavailability and unplanned outages – postponable and not postponable – unavailability. Planned unavailability refers to inspection and maintenance and repair work. Unplanned outage means that the operation of the plant cannot be continued as planned due to an incident or to damage. Distinguishing between postponable/not postponable helps in understanding the severity of the incident regarding the cost-effective operation of a power plant.

Figure 7 illustrates, in a simplified view, the high sensitivity of energy utilisation versus the costs of electricity production (CoE). The critical operation area for the power plant unit shown falls in the range below 4,000 annual full load operating hours (AFH).

Figure 7: Example for CoE for a 600 MW hard coal fired power plant



Source: VGB PowerTech e.V.

4,000 AFH correspond to an energy utilisation of 45%. If the plant fulfils this minimum requirement it will be profitable in the market and will generate a marginal return. If, due to a high unavailability or due to other market effects (e.g. preferential feed-in of RES power), the plant is operated for less than 4,000 AFH, the operation of the unit will cause considerable financial losses. This simple calculation demonstrates the importance of a power plant unit's energy utilisation rate.

Evaluation of availability and unavailability of Power Plants

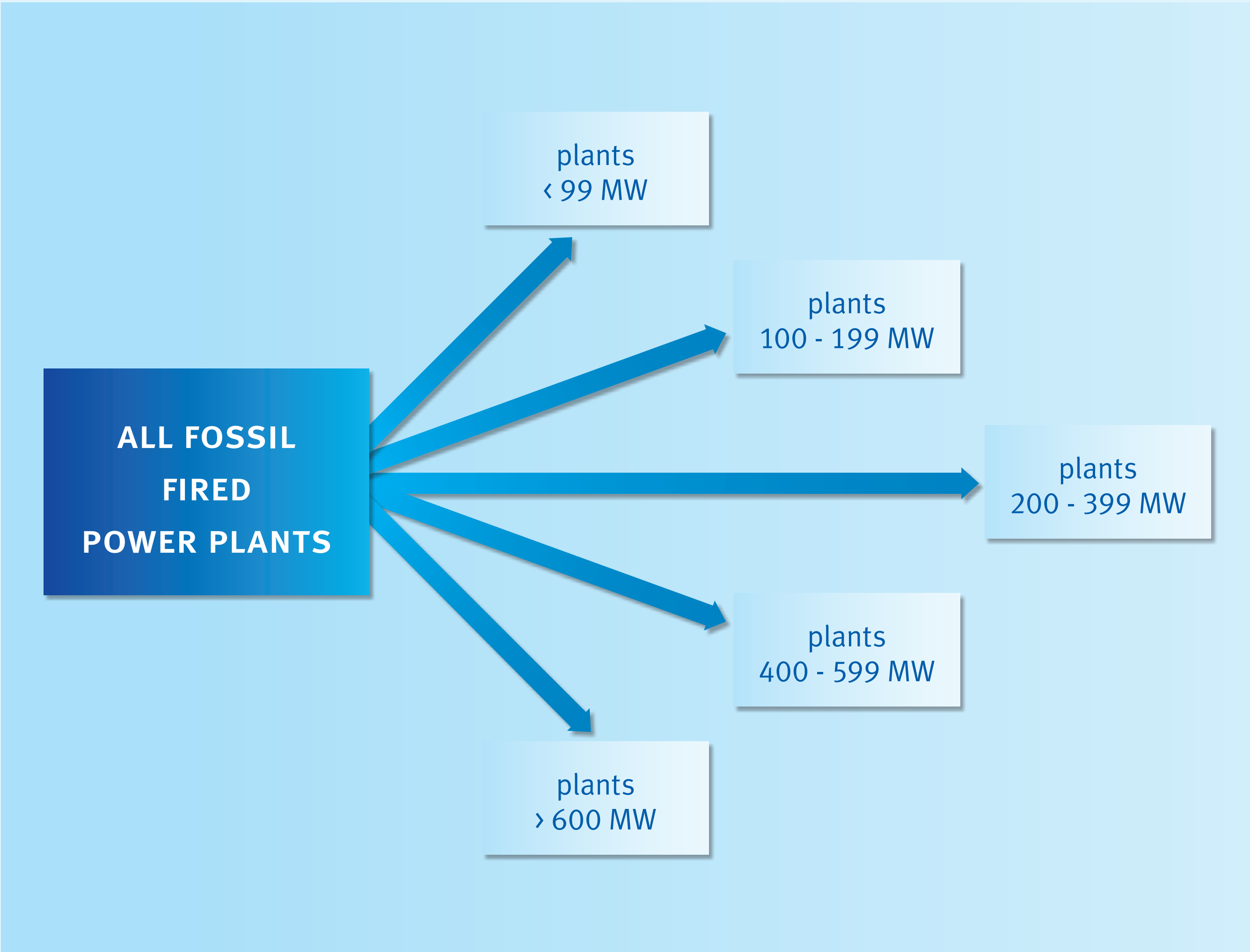
Availability of Power Plants

EURELECTRIC and VGB decided some years ago to merge their data collection for the availability and unavailability of power plants. The data are collected according to standardised uniform definitions and recording procedures.[7]

The following data evaluation is an extract of the annual report[8] and online evaluation tool KISSY(Kraftwerksinformationssystem = Power Plant Information System).

According to the European code of competition, data collection and data evaluation have to be anonymised. Therefore all collected power plant data are aggregated in peer groups.

Figure 8: Example for peer group analysis regarding capacity



[7] VGB Guideline “Fundamentals and systematic of availability determination for Thermal Power Plants”.

[8] VGB/EURELECTRIC – Availability of Thermal Power Plants 2001 – 2010.

The creation of peer groups ensures that all data from the power plants are evaluated according to similar technical characteristics such as:

Fossil fired units:

- size of power plant capacity
- fuels by capacity
- furnace type by capacity
- units by single or dual boiler operation
- units by sub-critical or supercritical pressure

Combined cycle units

Gas turbine units:

- Open circuit
- Jet Engine

Nuclear power plants:

- Reactor type
- Capacity
- Service life

The typical outcome of the standardised availability analysis is illustrated in *Figure 9*. The table shows the availability of all fossil fired units for the period 2001 to 2010. We assumed a power plant capacity of 115,603 MW for the EU countries AT, CZ, DE, FR, IE, IT, NL, PT.

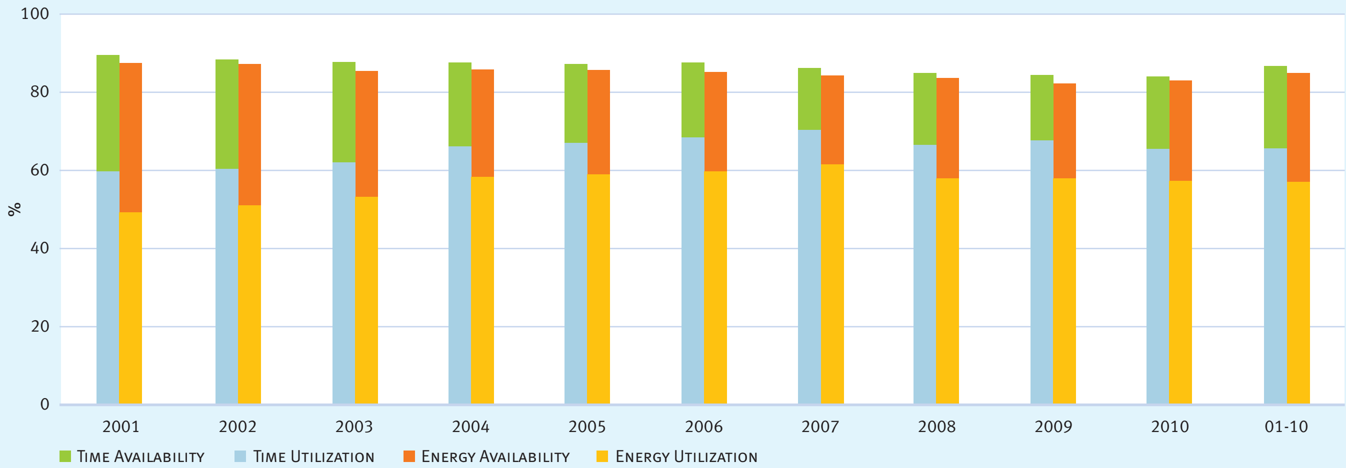
The top chart shows the quotient of the energy generated by the power plants and the nominal energy – which is the product of the nominal capacity and the reference period (calendar time). This “energy utilisation” changed from 49.2% (2001) to 57.2% in 2010.

Power plant operators whose fossil fired power plants do not reach the average energy utilisation of 57.0% have a clear indication that there is something wrong with their operation or operational maintenance strategy. The reference values for the plant’s “energy unavailability”, as illustrated in *Figure 9*, might provide a first indicator for the used maintenance philosophy. A detailed comparison of further indicators – such as “time availability”, “time utilisation” and the planned and unplanned part of the “energy unavailability” – between the analysed power plant unit and the statistics of the peer group analysis will provide further consolidated findings.

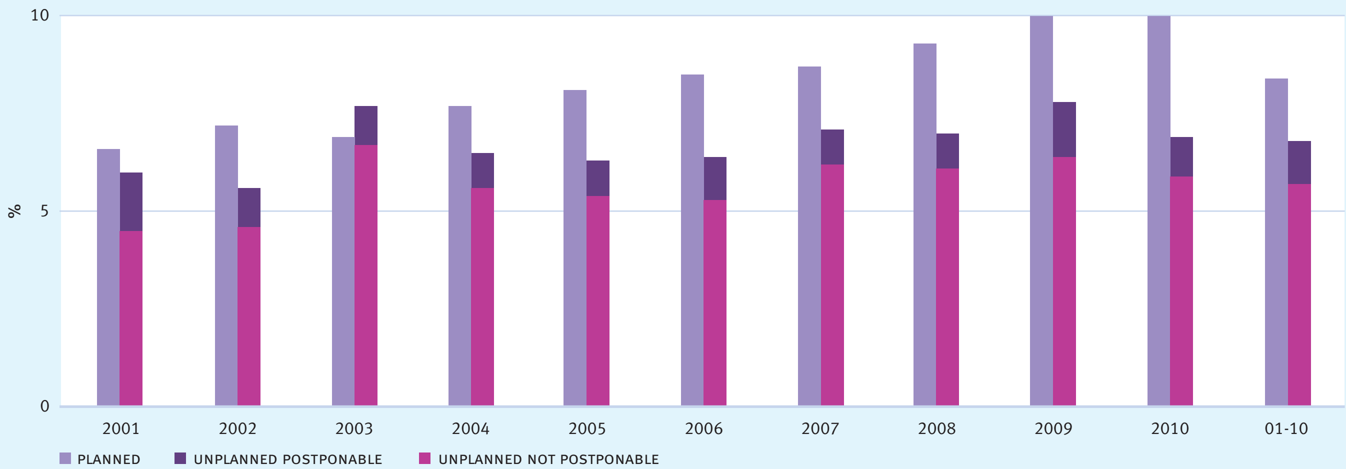
A more in depth analysis requires power plant operators to compare the “maverick” with a characteristic peer group composed of the same power plant capacity, fuel- and furnace type and operational conditions. This evaluation can be easily done if the power plant’s characteristics match one of the standard peer groups in the annual reports. If this is not the case, the power plant operator can create a specific online evaluation with the KISSY data base or mandate VGB with a special enquiry.

Availability of Fossil-Fired Units

Figure 9: Availability of fossil fired units (EU countries AT, CZ, DE, FR, IE, IT, NL, PT)



Energy unavailability



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	01-10
Number/Unit Years	245	237	239	311	313	313	317	315	308	316	2,914
Capacity (gross) (MW)	75,961	73,585	75,543	114,050	114,870	113,466	114,760	114,456	110,905	115,603	1,023,198
Time Availability (%)	89.5	88.3	87.7	87.5	87.2	87.5	86.1	84.9	84.3	84.0	86.6
Time Utilization (%)	59.6	60.3	61.9	66.1	66.9	68.4	70.3	66.4	67.6	65.4	65.6
Energy Availability (%)	87.4	87.2	85.4	85.8	85.6	85.1	84.2	83.6	82.2	83.0	84.8
Energy Unavailability (%)	12.6	12.8	14.6	14.2	14.4	14.9	15.8	16.4	17.8	17.0	15.2
planned part (%)	6.6	7.2	6.9	7.7	8.1	8.5	8.7	9.3	10.0	10.0	8.4
unplanned part (%)	6.0	5.6	7.7	6.5	6.3	6.4	7.1	7.0	7.8	6.9	6.8
postponable (%)	1.5	1.0	1.1	0.8	1.0	1.1	0.9	1.0	1.5	1.0	1.1
not postponable (%)	4.5	4.6	6.7	5.6	5.4	5.3	6.2	6.1	6.4	5.9	5.7
Energy Utilization (%)	49.2	51.0	53.1	58.2	58.9	59.6	61.5	57.8	57.8	57.2	57.0

Source: VGB PowerTech e.V.

Note: Data in this table covers data from AT, CZ, DE, FR, IE, IT, NL and PT.

Analysis Unavailability of Thermal Power Plants

Events which caused unavailability are analysed in the annual report “Analysis of Unavailability of Thermal Power Plants”.[9] The relevant data are collected online by member companies on an annual basis. As not all member companies participate in the more complex recording of the unavailability data, the analysis is based on different plant collectives. In the last reporting period from 2001 to 2010 a total of 89,103 unavailability events from 243 power plant units were evaluated.

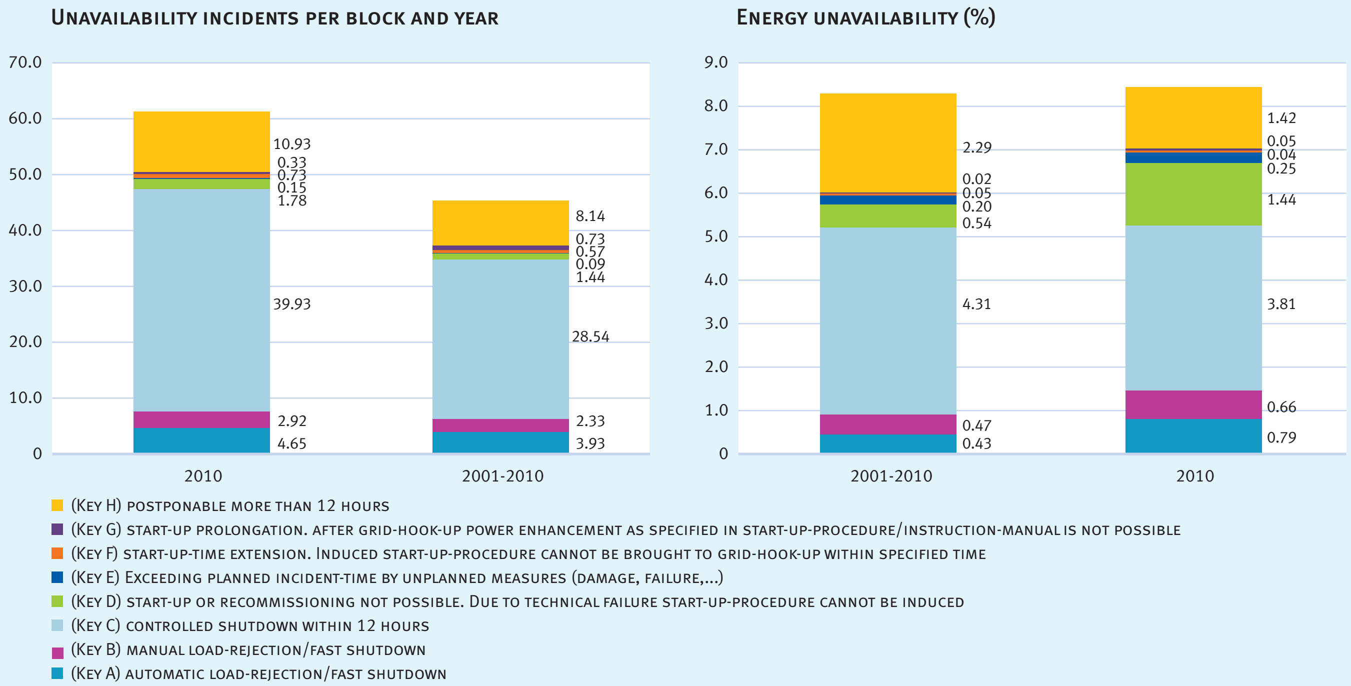
The unavailability events are described with an event characteristic key (EMS). The EMS was introduced in 2003. It avoids double and multiple recordings of events and allows a differentiated evaluation.

The following 12 different higher ranking event characteristic keys are in use:

- “Type of event”
  (outage, maintenance, modification, functioning test, etc.)
- “Operating status before event”
  (start-up, shut-down, stationary operation, etc.)
- “Operating status after event”
  (start-up, shut-down, stationary operation, etc.)
- “Impact on unit”
  (time frame for shut down, automatic load shedding/ emergency trip, etc.)
- “Outage impact on the components”
  (no or long-term effect, failure of component, etc.)
- “Cause”
  (design, manufacturing, assemble, inspection, operation, etc.)
- “Damage mechanism”
  (type of wear out, corrosion, ageing, violent usage, etc.)
- “Damage”
  (weakness of material, deformation of material, change of position, etc.)
- “Recognition of failure”
  (request of system/component, request of functional check, etc.)
- “Maintenance form”
  (maintenance method, cleaning, flushing, draining, ventilation, etc.)
- “Measures against recurrence”
  (change in construction, preventive maintenance, etc.)
- “Urgency of measures”
  (start of activities: at once, within 3 days, with fixed date, etc.)

In total, about 500 detailed EMS are defined for an accurate description of events. Although events are described by the cause defining keys, additional short statements are important in order to ease later evaluations. While the data gathering is complex, the power plant operator receives in return important system information for technical and economical plant optimisation.

Figure 10: Unavailability incidents of fossil fired units



Source: VGB PowerTech e.V.

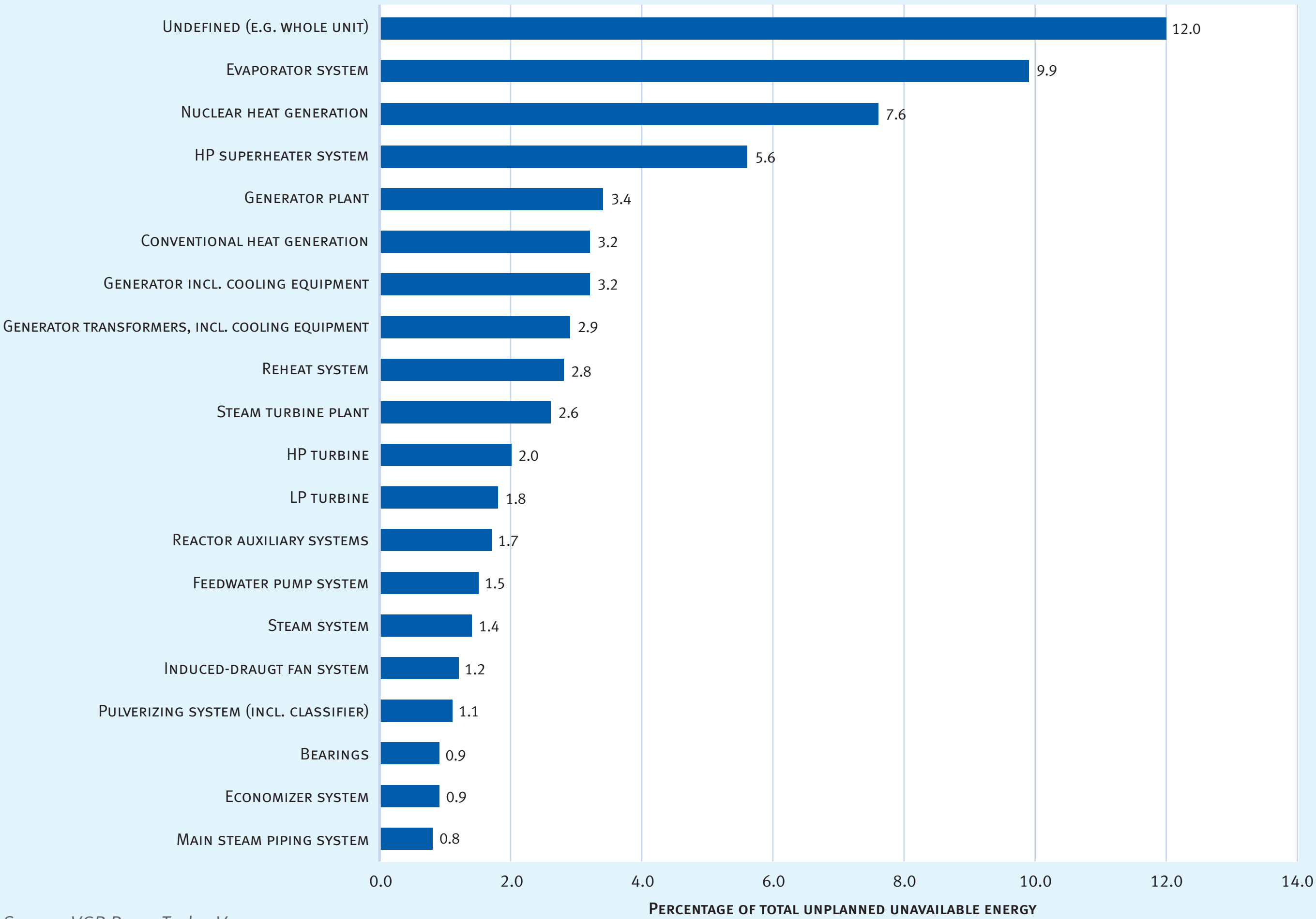
Note: Data in this graph cover a total of 89,103 unavailability events from 243 power plant units between 2001 and 2010.

[9] VGB/EURELECTRIC – Analysis of Unavailability of Thermal Power Plants 2001 – 2010.

Figure 10 shows a typical unplanned unavailability energy evaluation for fossil fired units for 2001 to 2010. In this example key A identifies the automatic load-rejections which caused an immediate shutdown. Key B describes the number of manual load-rejections which caused an immediate shutdown. Key type C represents the number of controlled shutdowns within 12 hours. Key D represents the specific situation in which start-up or re-commissioning of the power plant unit is not possible due to technical failures. Finally, key H represents the number of postponable incidents which allow further operation of the plant for more than 12 hours.

Figure 11 shows the main systems which caused unavailability. 58,256 incidents with a total of 440,161 GWh of unplanned unavailability energy were analysed from the countries CH, DE, IT, NL, PT for 2000 to 2009. Most of the unavailability in fossil fired units was caused by evaporator systems as well as high pressure super-heaters. In the case of nuclear power plants the heat generation in the conventional part of the power plants created most of the unavailability.

Figure 11: Main components causing unplanned unavailability energy of thermal power plants



Source: VGB PowerTech e.V.

Note: Data in this graph covers data from CH, DE, IT, NL and PT between 2000 and 2009.

Summary

The power statistics presented in this section give rise to the following, more strategically driven conclusions:

- **The contribution of the different power plants to the power supply:** In particular the effect of "firmness" is becoming more and more important when analysing the relation between postponable and variable power supply. The ratio of postponable to variable is an indicator for the system stability: the higher the postponable and the lower the variable supply, the greater the stability.

- **Average operating hours per year – after deducting outages:** The annual operation hours are an indicator of the operation mode of the power plants within the fleet. The analysis of these figures over several years shows the impact of the increase of RES on the supply system in connection with the regulatory issue of "must run" for the RES fleet. The decrease in annual operating hours for conventional plants will lead to severe difficulties in covering the cost of generation which means there are no incentives for the building of new postponable power capacities.

- **The reliability of the power fleet by the outage figures:** Outages – both planned and unplanned – are an excellent indicator of a plant's technical status.

  The planned outage is determined by the provisions made for repair work on damaged or aged components, for inspections of the condition of the components and for retro-fit measures necessary to upgrade the plant performance.

  The unplanned outage – with the distinction postponable/not postponable – illustrates the real condition of the plant and/or its components. The ratio of planned to unplanned outages indicates how "successful" the maintenance work is, as the goal of maintenance is to avoid damage during operation.

  Another important indicator which can be derived from the reliability figures is the impact of cost reduction measures driven by market pressure in terms of merit order. This is possible by comparing the planned/unplanned ratio over several years.

- **The outage probability of components and systems:** The forced, i.e. unplanned outage rate is an indicator of a component's outage probability. Both the average outage probability over the whole fleet and the comparison of selected power plants with the average enable the assessment of the ageing of components and the quality of maintenance work.

The four points above illustrate the relevance of consistently collecting and compiling statistical data – a tool which should be used more intensively in the future.

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