Energy know-how in a nutshell

POWER PLANT MANAGEMENT

A COMPLEX BUSINESS

THE OPTIMAL OPERATION OF A POWER PLANT, IN BOTH TECHNICAL AND ECONOMIC TERMS, DEPENDS ON MANY FACTORS AND IS A CORRESPONDINGLY COMPLEX MATTER.

Anyone who commits to a major investment hopes to reap the benefits for as long as possible. The construction and operation of a power plant is not unlike buying a car. The owner of a new car will take care of the vehicle and drive it as carefully as possible. His basic investment and ongoing expenses for items such as petrol and maintenance should therefore be kept as low as possible, while benefits in terms of comfort, driving pleasure and roadworthiness should be enjoyed as long as possible.

The owner and operator of a power plant also needs to keep constantly in mind the cost and revenue side of his investment to make it worthwhile. The profitability of a power plant depends on numerous factors, which make the operation of the plant a complex matter. Only by properly balancing expenses – such as for interest, depreciation, maintenance, personnel and fuel – and revenue opportunities through the sale of the produced electricity can production capacity be optimised and a good return on investment be achieved over the entire lifecycle of the plant.

Diversity is key

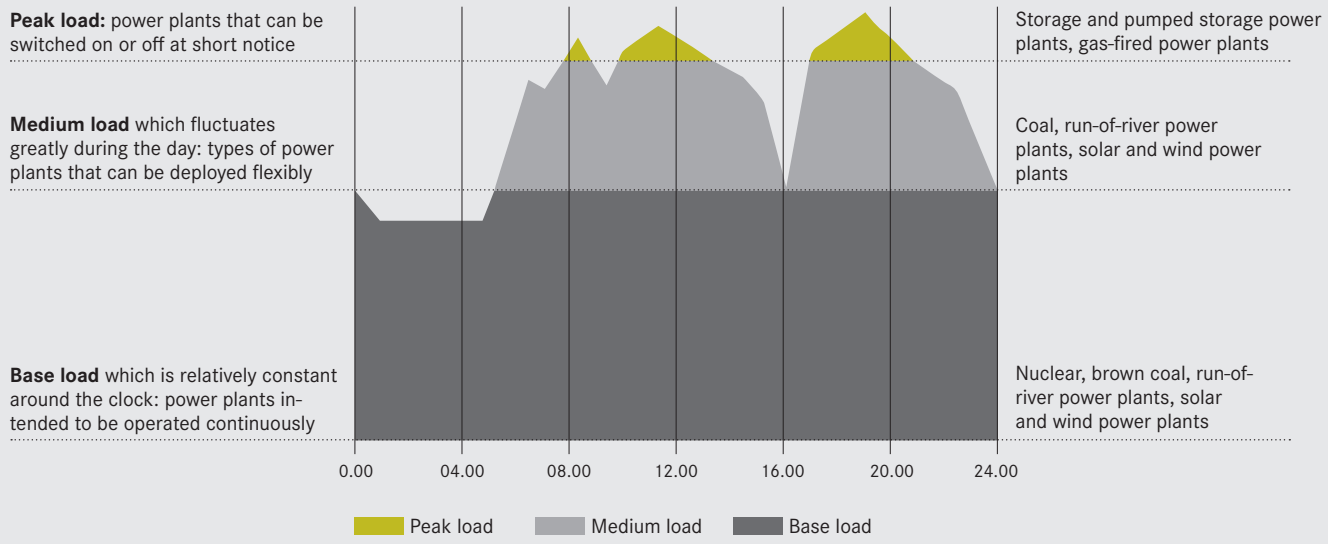
Two types of power plant need to be distinguished with regard to the costs for electricity production. One group involves a substantial initial investment in construction, while the variable costs for operation are relatively low (hydropower or nuclear power plant, new renewable energy sources). Conversely, the other group is characterised by relatively low investment costs but generates high variable operating costs (for example, fuel prices in the case of gas-fired power plants).

In addition to economic factors, social needs and physical conditions also play a crucial role in deploying a power plant. Since electricity cannot be stored in large quantities, the amount of electricity in the distribution grid at any one time must always be the same as that which is actually being consumed. Not all types of power plant are suitable for adapting flexibly to rapid changes in demand and market conditions (see graphic 1). To take account of this and ensure a secure supply of electricity at all times, various types of plant must be used together.

This interaction nearly always takes place on an inter-regional, and often international scale. The security of supply we have become accustomed to is the result of an intensive network of electricity producers, energy traders and utility companies operating across regions and countries. They trade electricity directly or on a number of energy exchanges, close gaps in supply and ensure that the grid is always balanced.

Graphic 1

How fluctuations in demand for electricity are managed



Everything to schedule

How is the deployment of various power plants and the use of the transmission systems for produced electricity planned and coordinated? Power plant operators and electricity traders submit daily schedules to the transmission system operator. These schedules provide information about when a specific amount of electricity needs to be transferred from one point on the supply grid (for example, a power plant) to another point (such as a large industrial concern). The grid operator collects all schedules that are relevant for its network area and ensures that the agreed energy exchange is transacted correctly and that the required, stable frequency is present in the electricity grid.

In practice, deviations from the submitted schedules are common: a cold snap, for example, can lead to an unexpected surge in demand, while local demand may drop due to a large factory suspending production. The result of this is that capacities in suitable plants must be immediately switched on or off. This so-called balance energy is also organised by the transmission system operator (TSO). The TSO puts the required capacities out to tender in the form of an auction amongst power plant operators. Based on economic considerations, these then decide whether to make their facilities available for this service or to operate them autonomously without restriction.

USING THE POWER OF WATER

HYDROPOWER IS THE DOMINANT RENEWABLE POWER SOURCE AROUND THE WORLD. IT IS RELATIVELY EASY TO CONTROL FOR USE IN POWER PRODUCTION.

The use of hydropower to generate electricity is widely used and proven. The first hydropower plants were already in use at the end of the 19th Century. Today they make up about 15 percent of Europe‘s power

plant portfolio. Further expansion of hydroelectric power is restricted as the majority of suitable streams and rivers are already in use.

Hydropower combines many advantages. Thanks to a long history of use, the technology involved has achieved a high level of maturity. Although construction costs for hydropower plants are comparably high, unlike electricity production based on fossil fuels there are no harmful air emissions and no variable costs for fuel purchase and environmental certificates. On top of this, the use of hydropower enjoys wide social acceptance and scores over other types of production with its high efficiency ratings of up to 90 percent. The disadvantage is that the construction and operation of hydroelectric plants can impact the local landscape and wildlife, which is why extensive measures for upgrading habitats for fauna and flora are often implemented in areas surrounding hydropower plants.

Accumulate, store, pump

Hydropower is harnessed by directing water onto a turbine, causing it to rotate and drive an electrical generator. In a run-of-river power plant, relatively large amounts of water fall onto the turbine from a small height. In the case of a pumped storage power plant small amounts of water are directed onto the turbine via a high-pressure pipe from great heights of sometimes over 200 metres.

The different types of hydropower plants are used for electricity production in different ways according to their characteristics. Run-of-river power plants use a relatively continuous flow of water, except in periods of drought or heavy rainfall. With a capacity utilisation of the turbine output of over 50 percent, they are mainly used to cover basic load and sometimes medium load requirements (see graphic 1).

Reservoir and pumped storage plants, by contrast, are used in a very targeted and flexible manner and often have a capacity utilisation of below 30 percent. Functioning as a kind of battery, they are the ideal type of power plant for responding rapidly to fluctuations in electricity demand (medium and peak load), which makes them the ideal choice for providing balance energy.

Remain flexible despite long-term planning

In order to continuously optimise the availability, costs and profitability of power plants, energy companies use their production capacity – in hydropower and other types of power plants – in many ways. In addition to long-term strategic planning, the opportunities currently provided by selling electricity on the market also play a role. Depending on revenue potential, an operator can, for example, opt for long-term direct sales of electricity to a specific customer, short-term trading on the international energy markets or the supply of balance energy to the grid operator.

FROM HEAT TO ELECTRICITY

THERMAL POWER PLANTS CONVERT HEAT ENERGY INTO ELECTRICITY. IF FOSSIL FUELS ARE USED, THEIR COST AND THE COST FOR CO_2 CERTIFICATES GREATLY INFLUENCE THE OPERATION OF THE POWER PLANT.

Much of the electricity consumed in Europe is produced in thermal power plants, which use uranium, gas, coal or oil to generate electricity. In 2009 around one-sixth of the power plant capacity in the EU was attributed to nuclear power plants and more than half to so-called conventional thermal plants.

Nuclear energy around-the-clock

The physical basis for power generation in a nuclear power plant is the release of energy through the controlled fission of uranium atoms. The resulting heat is used to produce steam, which is used to drive a turbine that is coupled to an electricity generator. The steam is eventually cooled and condensed back to water.

Nuclear power plants normally produce without interruption and help to cover the basic demand for electricity. This is partly due to technical reasons and the fact that nuclear power plant capacity can only be increased or decreased slowly. It also makes economic sense in view of the fact that the construction of nuclear power plants requires very large investments that can only be recouped by long and continuous operation. Nuclear power plants are operated under the strictest security measures. Because of the unresolved question of location, the issue of how to dispose of radioactive waste has yet to be fully solved.

Flexible gas-fired power plants

The driving of a steam turbine is also at the heart of the process for producing electricity in conventional thermal power plants. The re-

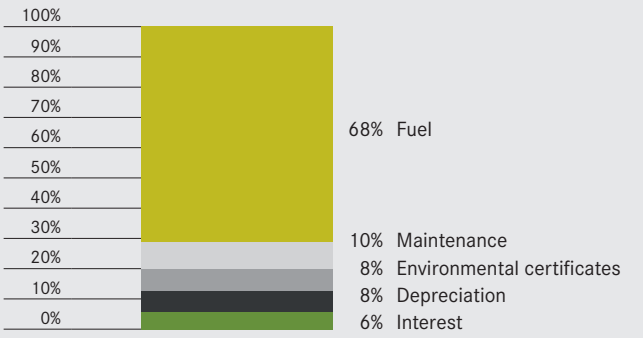
quired heat is generated by burning oil, coal or natural gas. In efficient gas-fired combined-cycle power plants, which have an efficiency factor well above 50%, electricity is produced using both steam and gas turbines.

The economically optimised operation of fossil fuel power plants is complex. Various factors come into play when weighing up the costs and revenue opportunities. For example, the cost of procuring fuel has a significant impact on the profitability of electricity production. The use of fossil fuels also means that power plant operators are always required to have CO_2 certificates, which are traded on the international market, and sometimes so called green certificates. Anyone operating a conventional thermal power plant thus needs to constantly monitor various influencing factors, weigh up the situation and decide whether it makes economic sense to use their production capacity and what strategy to use.

It is economically advantageous if a power plant can adapt its operation quickly and flexibly to market conditions. Gas-fired plants are particularly well suited in this respect. They are usually of a modular construction, which means that individual power plant units can be used separately. They can also reduce or increase their production relatively quickly. Some gas-fired power plants can even go from standstill to delivering their full power to the grid within a few minutes when this is economically viable for the operator.

Graphic 2

Operating costs of a gas-fired combined-cycle power plant



Operators of gas-fired combined-cycle power plants must keep in mind various factors related to cost and revenue. In addition to the current prices for natural gas and CO_2 certificates, the profitability of power plant utilisation is determined by the costs for operating the plant and its performance (degree of efficiency) and, of course, the electricity price being aimed for.

IN DEMAND, BUT HIGHLY UNPREDICTABLE

THE USE OF NEW RENEWABLE ENERGIES IS INCREASING SHARPLY IN EUROPE. THIS POSES A HUGE CHALLENGE FOR THE MANAGEMENT OF THE POWER SUPPLY.

The use of climate-friendly wind and solar energy as well as the small-scale use of biomass is currently enjoying a real boom. The worldwide installed capacity in wind power plants in 2010 increased by about one-fifth over the previous year, with the capacity in photovoltaic systems increasing by around a third. The biggest wind power producers are currently the US, Germany and China. In 2010 only 3.8 percent of electricity needs were met by wind power in the EU. However, extensive support programmes should mean that by 2020 their use onshore and increasingly offshore will enable them to cover around 15 percent of EU electricity needs.

In the area of photovoltaics Europe is already a key player. Around 75 percent of the world's installed capacity in solar power plants is now on European soil. And the annual growth rates are regularly much higher than those in other parts of the world. However, compared to other types of production, the contribution of solar energy is still low. In Germany, for example, only 2 percent of the electricity produced in 2010 came from photovoltaic processes (wind: 10 percent).

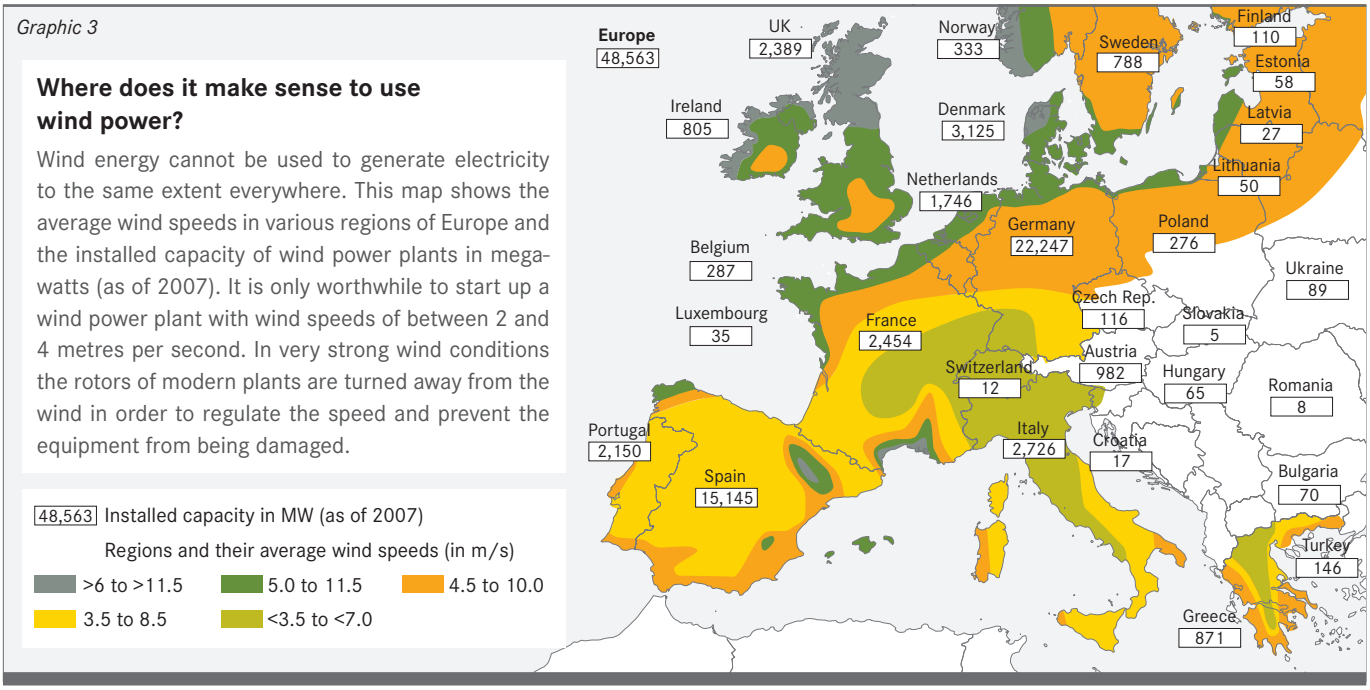
New economic factor

The boom in new technologies that make use of renewable energies is also having an economic impact. Germany, for example, is the world's second-biggest producer of solar cells after China, thanks to a funding scheme. Today around 100,000 people work in the German photovoltaic industry or in companies that provide important upstream services for the solar power industry. A similar number of people are employed in Germany in the planning and construction of wind

Graphic 3

Where does it make sense to use wind power?

Wind energy cannot be used to generate electricity to the same extent everywhere. This map shows the average wind speeds in various regions of Europe and the installed capacity of wind power plants in megawatts (as of 2007). It is only worthwhile to start up a wind power plant with wind speeds of between 2 and 4 metres per second. In very strong wind conditions the rotors of modern plants are turned away from the wind in order to regulate the speed and prevent the equipment from being damaged.



turbines and their operation. Worldwide, it is estimated that around 670,000 jobs had been created in the wind power industry by 2010.

Relying on the whims of nature

The yield of a solar or wind power plant is crucially determined by the prevailing weather conditions at the site. This why in Europe an increasing number of wind parks are being planned and constructed in the North Sea, where the winds are twice as strong as on land. Nevertheless, even if the best locations are selected for generating electricity from wind or solar power, the fact remains that there is a limit to how much this can be planned. For instance, it is only technically feasible to operate a wind power plant if wind speeds are between 2 and 4 meters per second. Added to which, the average number of sunshine hours varies enormously from one location to another, making the continuous use of solar energy difficult. In southern Spain, the solar radiation relevant for photovoltaic use is almost as double as strong as in northern Germany.

As the number of weather-dependent power plants connected to the grid increases so does the challenge to provide a secure power supply. Overall electricity demand or consumption does not take account of the current wind or sunshine conditions. As such, electricity suppliers must always be ready to compensate for a drop in electricity from wind farms by using the production of power plants at other locations (with different wind conditions) or which use alternative technologies. Conversely, a sudden burst of wind can lead to other power plant capacities having to be shut down to prevent an overload of the transmission system. In some areas of Europe (e.g. southern Germany) the distribution grid is already reaching its limits.

Quantity takes care of stability

The local unpredictability of production from wind and solar power plants is balanced by inter-regional or international exchange of electricity from new renewable sources. However, a prerequisite for enabling wind power from one region to compensate for a lack of solar energy in another region is the Europe-wide expansion of the transmission systems.

While an inter-regional perspective for using new renewable energy sources is necessary to ensure security of supply, it also offers attractive economic options. To make the most economical use of their facilities at various locations owners of wind farms can leave the running and marketing of the energy generated to specialised companies. These companies have both the requisite know-how and necessary contacts – to electricity buyers or energy exchanges, for example – for obtaining the best price for the electricity produced. And because they bundle the production capacities of various wind farms, they are able to guarantee a uniform supply of wind power to market, even if one or another plant is not currently producing due to a lack of wind. This stability through interconnection results in higher revenues for individual producers and marketers of wind power. It also increases the reliability of wind power as an energy source for today's society.

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