Impact of the energy transition on the electric power grid

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Aiming for de-carbonization of the energy sector by many countries as well as demands of the electricity market have a significant impact on the electric power grid. A vast amount of electric energy needs to be transported into various directions according to the market situation which was not the case in the past. With a fast growth of new renewable bulk energy sources such as wind and photo voltaic (PV) there is a geographic shift of production sites in relation to the load location. A situation which is enforced especially in Germany by shutting down nuclear units situated in or close to load centers. As a consequence in many cases greater distance and/or higher capacity of the transmission corridors are required.

The most significant problem, however, is created by the intermittency of the new renewable sources. Electricity production depends on the wind or sunshine conditions respectively, thus it is stochastic with limited predictability and it normally does not match the load requirements. Transmission system operators (TSO) in this way face an increasing challenge to maintain the system balanced and stable. As an example, though the installed capacity of wind and PV in a large German system is 65000 MW in 2013 the actual generation power was significantly less ranging between a peak of 35000 MW and a minimum of 148 MW. As a consequence a significant conventional reserve power have to be on standby to compensate for up to a major part of the load to deliver for a longer period of time, in case that the wind is not blowing for a week or more and/or there is a lack of sunshine. Operating the system gets more and more complicated. Unfortunately this fact is widely not understood and the physical terms of energy and power frequently are mixed up in public discussions.

In some countries based on the regulatory framework of subsidized feed in tariffs the renewable sources have priority in case of overproduction and create a market distortion due to the fact that TSOs have to market the RES at the power exchange even for negative prices. Thus conventional plants such as gas and hydro plants have to be shut down more frequently reducing their profitability. Investment for needed reserve capacities is hampered. Regulations need to be thought over urgently in the course of international cooperation. Switching off the renewable sources in case of overproduction may solve the problem to some extent but would be less environment friendly. Storing surplus of electric energy in pumped hydro plants in mountainous regions, e.g. in the Alps would compensate only to a small extent the planned growth of wind- and solar power in Europe - not taking into account the fact that in case of full exploration of pump storage the necessary transmission capacity is not there. The same applies when interconnecting countries or regions which might soften the problem. Regulations and rules how to operate system of quickly rising complexity are pending.

Speaking of Europe in any case the transmission capacity needs to be increased significantly. A strong overlay grid or strong backbones in particular from North to South are needed to solve the new allocation setting between generation and demand. Promising and quickly rising technology is High Voltage Direct Current (HVDC) transmission. As CIGRE’s work bodies have shown, even multi terminal HVDC links or HVDC grids seem to be possible in the near future. However, the problem is not lack of technology. The real problem are the Rights of Way (ROW) for the transmission corridors. In this aspect, politics is challenged to provide faster processing of the legal aspects. In time mediation with objective and unbiased information on the pros and cons of underground cable or overhead solutions is required.

On the consumer side drastic changes happen as well. New types of consumers such as electric vehicles and heat pumps are appearing in increasing numbers. From an operational point of view, however, the big problem is the quick penetration by a vast and growing number of little dispersed renewable sources, mainly PV unfortunately with intermittent generation into the grid. Consumers became producers and simultaneously they consume and produce quite often for a higher tariff with feed-in guaranteed. Regulations have to be thought over in particular for the case of overproduction. From an economical- and environmental point of view more dispersed electrical energy storage at the low voltage and/or on the medium voltage distribution level is desirable. It seems that growing research and development efforts are undertaken such as e.g. thermo electric storage and improved chemical batteries. Nevertheless, today’s distribution system is not sufficiently armed. Congestion numbers will increase and grid control is becoming enormously complex. Architecture and control systems have to adapt. Solutions are demonstrated in pilot installations, such as distribution automation including voltage regulation or micro grids with local intelligence combining into clusters. Smart metering pushed with tremendous efforts in a number of countries is certainly a first step to enhance customer’s consumption awareness but also to enable the necessary intelligence of the grid (smart grid).

Summing up it can be stated that the “energy transition” has a severe impact on the electric power system on all voltage levels. Degree and speed of implementation certainly depends on the needs and economical capability of the various countries. Questions arise not only whether a realization out of a “blue print” is actually affordable but also how to cope with different speed of implementation in the various countries. Both increase of international cooperation between countries as well as between TSOs, DSOs and industry is desirable. Solutions should aim for international consensus/standardization rather than on company standards. Engineers, scientists, economists and politics are challenged alike.

The International Council on Large Electric Systems (CIGRE), as a global, unbiased and objective institution, is well equipped to deal with all these matter. For the time being about 130 international CIGRE work bodies cover the scientific, technical, economic and environmental aspects.