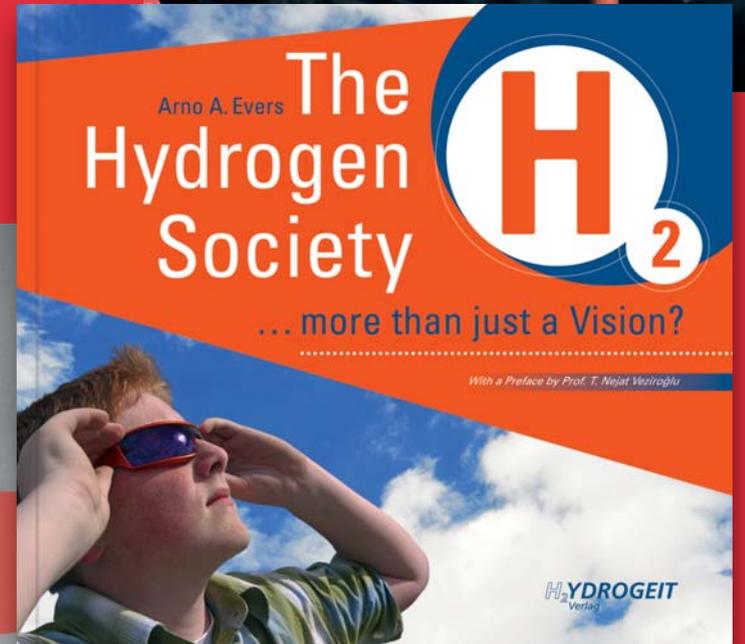


Available now! Arno A. Evers' The Hydrogen Society

First released at the HANNOVER MESSE 2010,
April 19 – 23 > Get your book here



3

The Grid: A Matter of Perspective

Today's global high voltage electricity network is a grid in which electricity moves in one direction from suppliers (mostly centralised power plants) to customers. It is accused of being inefficient, and there are calls that it should be promptly updated to become "smarter". This is a worldwide initiative that is currently being heavily funded by governments as a way of addressing energy independence, global warming and emergency resilience issues. To understand the development of our existing grid, one has to look back in history.



HYDROGEIT Verlag

Impressions

The Grid: A Matter of Perspective

During the initial years of electricity distribution, direct current (DC) was launched into commercial use by Thomas A. Edison (1847 – 1931) "The Wizard of Menlo Park" and first adopted in Manhattan, New York, where it became the standard for electricity in the United States. The beginning of industrialization saw increasing power consumption at huge sawmills and later steel- and aluminum factories or in textile and car manufacturing sites, and meant that in nearly all cases it was not possible to produce electricity where it was needed most. All the growing mega cities did not really allow for building huge DC electricity plants downtown or within the developing areas. Some are now museums or living quarters, like Bankside Power Station at the River Thames in London, which is now the famous Tate Modern Museum, visited by more than 30 million people since 2000.



A similar development was seen in Germany: here the first hydro power plant was connected in 1891 over a distance of 175 km (110 miles) from Lauffen to Frankfurt/Main to light the World Exhibition there. Later, steam power plants laid the foundation of our existing electricity system, connecting turbines, generators and transformers (see chapter 2, Turning on the light: The Process of Electricity Generation). Somehow the electricity had to meander its way through to come from A (production in the power plants) to B (use in industry and households). This was pioneering work back then, appealing to the engineers and entrepreneurs at that time. After a competition between Thomas A. Edison and his companies and a group consisting of Nikola Tesla (1856 – 1943) at Tesla Electric Light & Manufacturing and George Westinghouse (1846 – 1914) from "Westinghouse Electric Corporation", the usage of alternating current (AC) finally won! This was mainly because AC was, at least with the technology of that time, easier to transform up to high voltage and down again. This was done in order to reduce the energy losses during transportation, especially over long distances. This was the state of the art way back, one and a half centuries ago. Today, under current conditions and with knowledge of new technologies the decisions to use AC may have been made differently. Especially when one considers that the power losses are estimated to be about 7 percent of the electricity supplied to the grid. But the grid is now in place and working, so why change it? As long as the primary energies used (mostly coal) are as cheap as they are, there was and is no reason to change the supply infrastructure.

http://en.wikipedia.org/wiki/War_of_Currents

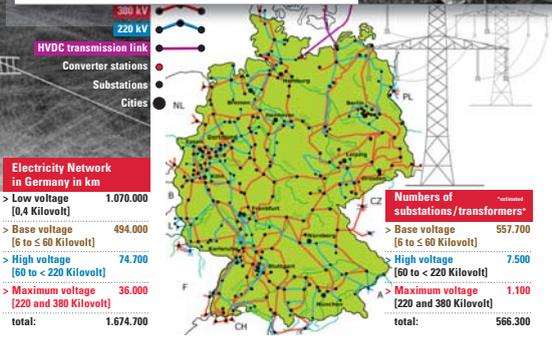
3 The Grid

Basically since the late 1880s we transform electricity in transformers at substations to voltages between 15 kV (introduced in Germany in 1891) to 110 kV (introduced in Germany in 1912), later to 220 kV (introduced in the USA in 1924) to 380 kV (introduced in Germany 1957) to 500 kV (introduced in USA and former USSR in 1963) and finally up to 735 kV (introduced in Canada in 1956).² The latest trend is to implement high voltage direct current long distance lines (HVDC). Some of them are in daily use in India, China, and Europe already, and are planned for the DESERTEC project between North Africa and Europe in 2015 or later.

But let's go back to Germany, a relative small country, stretching around 1,000 km (620 miles) from north to south and around 600 km (370 miles) from east to west. At the moment, as a result of the historical development briefly explained above, electricity is carried from the power plants through a transmission network of high voltage lines at 220 kV and 380 kV to substations, where the voltage is then stepped-down to 110 kV for load points (localities, industrial areas, villages, etc.) or to 20 kV (base voltage) for industries or further distribution to low voltage lines (Figure 3.1). Here additional transformers are again used to step the voltage down to 0.4 kV for distribution to commercial and residential users.

Sadly enough, these voltage lines run for thousands of kilometres. In Germany this network consists of almost 1.57 million kilometres (1 million miles) of transmission lines. 94 percent of them are dedicated to the transmission of low voltage (0.4 kV), 566,300 transformers/substations are used to step up and down the voltage, 98 percent of them for the base voltage network.

² Hrolik, Klaus et al. Elektrische Energieversorgung. Vieweg Verlag 2004, page 9



from his book

3 The Grid

When you look at the map of Germany, you can hardly image that literally 1,000 power lines are running in parallel both in north-south and east-west direction. All this effort, just to bring electricity to industry, commerce, and small and medium enterprises; not to mention the plugs in your homes or apartments. The actual problem lies in the order of magnitude and the rather antique nature of the global grid and its infrastructure, as it exists today. In most cases, the lines are old: some of them tend to fall during snowstorms in Winter. Some substations and their transformers date back to the 1940's. Sometimes it is like a miracle that it all is actually still running. Just ask insiders of this system and they will tell you how lucky they sometimes are to overcome their day or night shift without remarkable failures. When comparing this to the grid in the US or in China, or in India it is even more complicated. The confidence, however, that pervades the views of our utilities, grid operators and governments in our centralized energy system is startling. Just look at the next page to find the U.S. Department of Energy's (DOE) definition of the electricity grid, which they wrote after the failure of the U.S. power grid at the east coast in August 2003.



At this point we have arrived at an impasse, where we spend too much time trying to keep an infrastructure which actually changed little since Thomas A. Edison switched on his first electric illuminating system on September 4, 1882.³ There's no particularly urgency to move things along, since each of us has all the (cheap) electricity he or she needs, although there are promising proposals for a resolution. Countries around the world are just starting to integrate advanced technologies that will help to build a more efficient and more resilient electrical grid, in short: to make it "smarter".

³ <http://www.orned.com/history/electricity.asp>

3 The Grid

... as described by the U.S. Department of Energy in 2004

The power system is an engineering wonder. Every second of every day, power generators produce exactly the amount of electricity that consumers require when they turn on lights. With a minuscule amount of storage on the system, electric utilities and grid operators continuously perform a complicated balancing act. Grid operators schedule power flows across transmission lines to meet the supply and demand of the market. Worldwide, there are 50,000 large and small generating stations. Most of them are connected in regions, states, countries or even continents like Europe electrically and are spinning in perfect unison. They generate electricity, which is transformed up and down in different steps to provide consumers with 120 V at 60 Hz (Europe, Asia: 230 Volts and 50 Hz). Large customers in industry receive higher voltage due to their higher consumption. Any deviation from this combined balance can cause grid instability that could damage power plant and transmission equipment. Obtaining custom-built replacement parts for some of this equipment, such as large steam or generating turbines, can take months or longer. Damage occurs very quickly, and all this equipment is expensive, so complex computer and management systems are in place to guard against failure. The primary protection are breaker switches that switch the line off automatically if electrical parameters such as frequency or voltage stray outside narrow boundaries. Electric power plants to come on-line and cycle off to meet the ebb and flow of demand. They also direct traffic on the transmission system for a specific territory. Their work is much like that of air traffic controllers, who are bombarded with data and must make quick decisions based on computer simulations and their understanding of the system. In a nutshell, their job is to detect the conditions that cause blackouts, implement steps to avoid them, and restore normal operations as soon as possible. In regions that have them, regional transmission organizations provide input to system operators about conditions outside their control areas that might affect operations.

Data Source: <http://www.doe.energy.gov/smartgrid.htm>

H₂HYDROGEIT Verlag

34,50 Euro ISBN 978-3-937863-31-3

www.hydrogeit-verlag.de/shop

www.hydrogenambassadors.com

