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Grids and storage systems – The next challenge in the energy transition

The international climate targets can only be achieved with a global energy transition and thus a fundamental transformation of energy systems. However, and until now vastly underestimated, the transition from fossil fuels to renewable energy (RE) will also change the way electricity is supplied: in the future, the energy landscape will no longer be dominated by centralised large-scale power plants that generate electricity continuously, but by decentralised solutions and a volatile electricity supply. This increases grid requirements in combination with modern storage capacities. In fact, the energy transition cannot be achieved without this next "frontier" of energy systems. This means that much more attention needs to be paid to grids and storage systems than in the past.

Rapid increase in renewable energy sources

The development of renewable energy is a success story that hardly anyone would have thought possible just a decade ago. Although the shift to sustainable energy may not be happening fast enough in view of the threat of global warming, the energy sector has changed faster than any other climate-related sector. This is certainly true for the first part of the energy transition: the expansion of RE in the electricity sector. It now accounts for 33% of installed generation capacity on a global scale. In 2018 alone, the share of electricity from renewable energy sources grew by 7% worldwide, thus supplying an additional 450 terawatt hours (or 450 billion kilowatt hours) to global power grids. In 2018, for the fourth year in a row, more capacity was added for electricity generation from renewable sources than from fossil and nuclear energy combined.

This figure alone shows that the trend is irreversible. "Renewable energy sources have established themselves on a global level," says the REN21 network (Renewable Energy Policy Network for the 21st Century). Solar energy experienced the strongest growth, followed by wind energy and hydropower. All three are now competitive with electricity from fossil fuels. Since 2010, the cost of solar energy has fallen by approx. 90% and that of onshore wind power by approx. 35%, with the result that hydropower, which dominated the RE market just a few years ago, now plays a secondary role in relation to new electricity capacities.

This expansion has long since moved beyond the industrialised countries, and 53% of all investments have been made in emerging economies and developing countries. A trend that has already existed since 2015. In addition to many industrialised nations, countries such as Brazil, India, Turkey, Mexico and the Philippines are among the top countries in terms of electricity production from RE.

Electricity supply is changing: decentralised and volatile

However, with the increasing share of renewable energies in the electricity mix, the "character" of electricity supply is also changing. Where large, centralised power plants with traditional transmission infrastructure used to dominate, smaller decentralised structures are now increasingly emerging, some of them in

very remote areas. Where capacities could previously be planned using fossil fuels, renewable energy sources are much more variable because the wind does not always blow at the same speed and the sun does not always shine with the same intensity. The requirements for grid management and digitalisation are thus on the rise.

The combination of geographical disparity and natural fluctuations when energy is produced from RE makes it all the more necessary and imperative to focus on grids and storage systems. They are the neuralgic points for electricity supply from RE because they can bridge both geographical distances and obstacles – in some cases across national borders – as well as periods of less availability. It is therefore important to use modern grids and storage systems to counteract the decreasing system stability caused by using more RE. This includes, specifically:

- Compensating for the volatility of feed-in from the increased use of RE.
- Keeping the mains frequency and voltage stable to avoid power failures and damage to electrical equipment.
- Absorbing and cushioning short-term power peaks in electricity production through (e.g. compressed air or battery) storage.
- Connecting remote power plants to the grid.

Quote

"Wind and solar are critical pillars of the world's efforts to tackle climate change, reduce air pollution and provide energy access to all. Their declining costs are a huge opportunity. But power systems need to become more flexible and market designs must be adapted in order to avoid unintended impacts on electricity security."
Dr Fatih Birol, Executive Director of the International Energy Agency.

Supply systems therefore need to be more robust and flexible at the same time. They must reduce losses, while at the same time connecting and integrating RE to ensure continued energy security. This is exactly what is lacking, not only in developing countries, but especially there, because up to now, if at all, the focus has been on RE expansion.

Demand for electricity is increasing in all regions of the world

What's important is integrating RE, especially because the demand for electricity will increase significantly in the future. And for a number of reasons: first, some 900 million people still have no access to electricity. Second, digitalisation requires a lot of electricity and third, various sectors now rely on electricity that used to run on fossil fuels: this applies, for example, to the transport sector (electromobility) or the building sector (electric heat pumps for heating and cooling).

According to the International Energy Agency (IEA), the number of electric cars has increased from three to five million in a single year. It says that electromobility is increasing rapidly. We are heading for a world where devices and buildings are smart and run on electricity. This is also true – with some delay – for developing countries. "Electricity is the fastest growing part of final energy consumption," says the IEA. And in all of the scenarios and forecasts for the coming years, this growth – not least because of climate change mitigation – will be made possible with renewable energy.

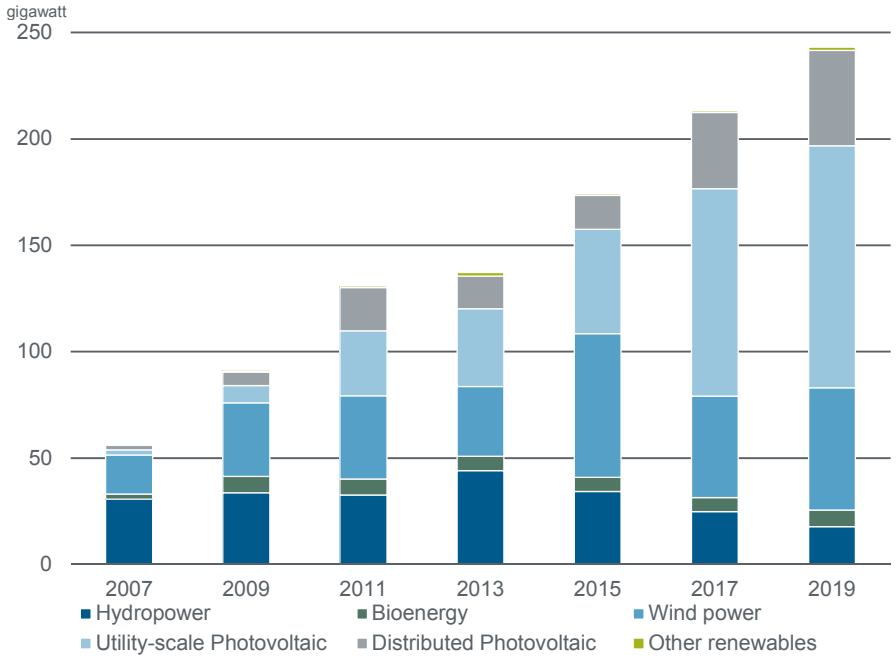
In Germany the energy transition is reaching its limits

The possible implications if the grids do not grow in line with the capacities of the RE are shown, for example, by the case of Germany. Here, the energy transition is also being slowed down because electricity from wind power, which has so far made up most of the RE, is mainly produced in the north of the country, including off-shore, but the high-consumption centres tend to be located in the west and south. This results in a time lag and physical gap between production and consumption that the existing grids cannot compensate for.

Especially since merely adding power plants – without expanding the networks – means that plants have to be shut down, but the operators still receive their forecast compensation. "Without suitable grids, a lot of electricity from renewable energy sources goes unused. Producers still receive guaranteed payment for supplying the energy, which is not optimal from an economic point of view," says the German Federal Government about the German energy transition. Electricity grids would have to be optimised, upgraded and in some cases new ones built.

The wind power capacity available at any time in Germany, for example, is less than 1% of installed capacity, even though it accounts for around 19% of German electricity production. This means that wind power hardly makes a reliable contribution to providing capacity in Germany at present. In line with this, the German Energy Agency says: "To ensure that renewable energy sources can be significantly expanded on an ongoing basis as needed, it is essential

Growth in renewable electricity capacities by technology



that the pace of expansion of the electricity grid is significantly accelerated and that the electricity grid capacities are optimally utilised."

Transmission lines for Albania

Albania's electricity generation is based almost entirely on hydropower and is therefore already very climate-friendly. However, the country regularly suffers from periods of drought, which reduce the supply of electricity from hydroelectric power plants. The problem will only get worse because climate models predict that heat and drought periods will be much more frequent. To avoid power cuts on the one hand and the construction of fossil power plants on the other, it is very important for Albania to exchange electricity with neighbouring countries. Between 2004 and 2016 KfW committed development loans of around EUR 130 million on behalf of the Federal Ministry for Economic Cooperation and Development (BMZ) to finance transmission lines with three neighbouring countries – Montenegro, Kosovo and Northern Macedonia. To further integrate Albania into the European grid and to improve the technical and regulatory framework of the energy sector, further concessional loans are currently being prepared. These aim to digitalise grid management and energy market reforms.

China is expanding renewables, but wind farms are at a standstill

Storage capacities and grids are also a limiting factor in China. The country is one of the leaders in renewable energies, especially wind energy. A new wind turbine is installed there every hour. In the meantime, almost 100,000 turbines supply an output of around 150 gigawatts, almost twice as much as in the USA. But at the same time, entire wind farms have to be deactivated, i.e. taken off the grid due to bottlenecks.

This figure is as high as 39% in Gansu province according to the IEA. The reason for this can be found in the grids, which simply do not have enough capacity: the wind farms are often located in remote areas, and the high-voltage grids are stretched to their limits when they are supposed to transmit the enormous amounts of wind power to the consumption centres.

This creates an absurd situation in which sustainable electricity is produced on a mass scale, but cannot be transported to the consumer. An impressive example: power generation is only one factor on the road to the energy transition; stable grids and storage systems are two other important ones.

Billions needed for investment

Fixing this problem will take time and above all money. In Germany alone, the increase of RE in the energy mix will result in investment costs amounting to billions. dena estimates the costs for the expansion of the transmission grids up to 2050 to be between EUR 79 billion and EUR 107 billion more than previously planned. This is necessary, they say, in order to be able to integrate the ever increasing quantities of renewable electricity

The distribution grids must therefore also be adapted to handle not only the increasing share of renewable energy but also the higher loads caused by new electricity uses such as electromobility and heat pumps. dena estimates the additional costs in this area to be between EUR 146 and 253 billion. And this is only the case in Germany, which already has solid transmission and distribution grids compared to the emerging economies and developing countries.

"Green corridors" for India

India wants to meet more of its energy needs with RE. However, the promising regions are almost all far from the economic centres and are concentrated in a small handful of regions. This is why the country is establishing "green corridors". India thus supplies sustainable electricity to the national grid and transports it to where it is needed most urgently. KfW is supporting India in expanding its network on behalf of BMZ with a total of EUR 1.4 billion. It is working both with transmission companies in various individual states and with the largest national grid operator – with the aim of expanding the grid and making it more stable with new lines and substations.

Importance of storage for the Paris climate target and SDGs

According to the UN, the use of RE must accelerate rapidly. First, in order to achieve the target of well below two degrees Celsius set in the Paris Climate Agreement. This is because energy accounts for the largest share of greenhouse gases, around two thirds, and thus plays a major role in climate change and global warming. And second, to achieve the SDGs (Sustainable Development Goals), because around 900 million people still do not have access to modern energy; 2.8 billion people depend on wood, coal or dung for cooking and heating

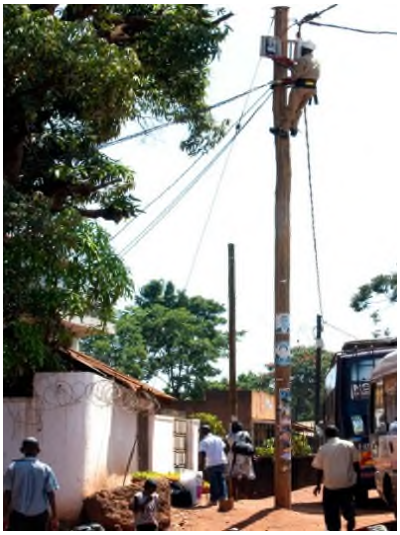
However, expansion will only succeed with more storage capacity. In general, there are several ways to achieve the

greater flexibility in the electricity grid required by RE: complementary gas-fired power plants, interconnectors with other countries, storage water or pumped storage power plants, other storage solutions or demand management. However, gas-fired power plants are climate-relevant and therefore not the preferred solution. Cross-border electricity connections are not always possible and often take a long time to build. This is why storage systems are particularly suitable, but in many places the topographical requirements for storage water or pumped storage power plants are not met, for example because areas have to be floodable or because the corresponding differences in altitude are lacking.

Regional power grid for West Africa

West Africa has great potential for cost-effective wind, solar and hydropower, but this is unevenly distributed across the region and not yet sufficiently developed. To harness this potential, further capacity expansion and a shift from national to regional electricity supply with powerful and flexible grids are needed. This is why the ECOWAS states founded the West African Power Pool (WAPP) to create a regional power transmission grid. On behalf of the German Federal Government KfW is promoting various transnational transmission lines, e.g. Togo–Benin or Senegal–Gambia–Guinea-Bissau–Guinea, as well as the expansion of various RE-based power plants. In addition, small energy storage systems are being established in donor-financed photovoltaic projects to make it possible to plan solar energy in the grid.

Battery storage systems, on the other hand, can be used as modules – anywhere in the world with minimal preparation and design effort. The biggest disadvantage in this area are the high investment costs. Grants from international donors would be all the more crucial here, especially since it can be cheaper to build storage systems than to lay transmission lines to peripheral areas. They could also accelerate the use of small stand-alone solutions based on RE.



KfW: A leader in renewables, but electricity grids still need work

KfW is one of the largest financiers of RE in the world. Over the past five years (2015–2019) KfW Development Bank has committed around EUR 5.5 billion for this purpose. At the same time, grids and above all storage systems played an important, albeit much smaller, role in funding practice. Projects include the following: In Albania, for example, the focus is on electricity trade with neighbouring countries; in India KfW is financing transmission lines to transport electricity from RE to other parts of the country. In West Africa it is promoting a regional electricity transmission grid, and in Tunisia the first grid-connected battery storage facility in North Africa is being built with KfW support. These are some promising examples. The demand, however, is much greater.

Conclusion

The expansion of volatile renewable energy sources in electricity generation requires options for flexibility in order to maintain the security of supply even if supply fluctuates. In addition to geographical diversification, e.g. in the form of large-scale grid networks, storage systems in particular are gaining in importance. They can be deployed anywhere and can compensate for fluctuations in supply. What the solutions look like in detail depends on the conditions on the ground. What is clear, however, is that the shift to renewable energy sources will not be complete or will come to a standstill unless the respective electricity grid is also modified. Examples from Germany and China clearly demonstrate this. The same applies for developing countries. Here, the electricity grids and storage systems must be adapted in parallel with the expansion of RE. As investment costs are high, extensive financial support or favourable financing options are required. This is therefore also an important task for international donors – especially if they are committed to climate financing.

A battery storage system for Tunisia

Tunisia is heavily dependent on energy imports, but at the same time has considerable potential for renewable energy. The country is very sunny and there is a lot of wind along the coast. To harness this potential, Tunisia has set itself ambitious targets for RE expansion: it aims to increase its share from a few percent to around a third of primary energy consumption by 2030. KfW Development Bank is helping Tunisia to achieve this goal. On the one hand, it has financed or prepared a number of solar and wind power plants, and on behalf of BMZ it is also promoting North Africa's first grid-connected battery storage facility. It is being built near the city of Tozeur, where two KfW-financed solar farms are currently under construction. When the storage tank goes into operation, it will be able to absorb electricity from the solar farms and from the public grid, thus optimising and stabilising the grid.

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