Innovation as the missing piece of the grid expansion puzzle

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Germany must massively expand its electricity grids for the energy transition. The current focus is on established cable technologies. Alternatives could reduce costs, writes John Fitzgerald, CEO of the start-up Supernode, which specializes in superconductors. What is needed is innovation-friendly regulation.

While renewable energies are being expanded at record speed and the demand for electricity is also increasing rapidly, **grid expansion** cannot keep pace with this expansion dynamic and threatens to jeopardize the success of the energy transition. The necessary infrastructural requirements were recently outlined in the **2037/2045 grid development plan**. According to the Federal Network Agency, the investment volume required for the **expansion of the transmission grid** by 2045 amounts to **320 billion euro**, with additional costs of just over 200 billion euro for upgrading the distribution grid.

Politicians discuss expansion costs

Grid fees recently doubled at the turn of the year, as the state subsidy from the Economic Stabilisation Fund was removed. For this reason, the **financing** of grid expansion has become the focus of political debate. The **energy ministers of the federal states** recently found that the considerable investments required to finance the grid expansion costs could not be covered by electricity grid fees alone and thus by consumers. In addition, politicians from the SPD and CDU parliamentary groups have called for an **end to the priority of underground cables** and for new transmission grids to be built as overhead lines, which should lead to savings of at least 20 billion euros.

However, the return to overhead lines is not without risks: Although they are cheaper, they meet with great **resistance from the local population** due to their interference with the natural scenery and local wildlife. However, conventional underground cables also pose obstacles to rapid and targeted grid expansion due to the necessary **civil engineering work** and **soil erosion**. In addition, conventional cable technologies based on large quantities of copper or (steel) aluminium pose supply risks.

The current discussion is therefore misguided, as neither technology is capable of upgrading the grids for a renewable electricity system. One element that has so far been ignored is the role of **innovation** and novel cable technologies that **complement conventional technologies** and can supplement the electricity grid moving forward.

Electricity grids need innovation

By the target year 2045, Germany will need a total of **25,723 kilometres of lines** to manage the **integration of renewable energies**. Conventional cable technologies will be able to meet some of the challenges, but innovative cable technologies with high transmission capacity based on superconductors are also required to ensure the stability and functionality of the German electricity grid in the future. This was rightly recognized by the **EU Grid Action Plan** and the 8th Energy Research Programme of the **German Federal Ministry for Economic Affairs and Climate Action**, which list superconducting cable systems as important future technologies.

The special feature of **superconducting cables** is that their electrical **resistance disappears at temperatures of minus 200 degrees**. Less electrical resistance makes it possible to transmit more power via a link. This increases the transmission capacity of the network. As a result, the transmission capacity can be better and more flexibly synchronized with the high expansion capacities of renewable energies in the future.

Lower demand for raw materials

In addition to the energy policy objective of a high-capacity grid, superconducting cable systems can also greatly limit the **impact on the environment**. The cables require a corridor of only one to two meters (overhead line 50 to 80 meters, underground cable approx. 25 meters) and are not dependent on electricity pylons or intensive civil engineering work. The narrower transmission corridors open up new possibilities for routing the lines, which means that social objections to grid expansion can be avoided.

One issue that has so far been completely ignored in critical infrastructure such as the electricity grid is the **demand for raw materials** and the associated resilience of supply chains. According to the **IEA**, **152 million km of electricity transmission cables** would be required to achieve the net-zero target. This would require 427 million tons of copper, i.e. around half of the global copper reserves, which are estimated at 870 million tons.

If such a quantity of **copper** were used for electricity transmission, there would not be enough copper available for wind turbines, batteries, and other technologies of the future. Superconducting cables can mitigate raw-material usage conflicts because they require **seven times less copper than conventional** copper-based cables.

Innovative edge – build on it or lose it

High-temperature superconductors were discovered by the German physicist **Georg Bednorz** in 1986, for which he was awarded the **Nobel Prize in Physics** the following year. Since then, Germany has been able to maintain and further expand its knowledge lead. The KIT and the Max Planck Institute, for example, are global leaders in superconductor research.

However, this lead threatens to diminish due to the lack of application of the technology in the electricity grid. **Electricity grids are an important market for the future**. It is therefore imperative to avoid shifting the value chain abroad, as is the case with the solar industry, for example.

A basic prerequisite for this is the **testing** of the technology through **pilot and demonstration projects**. However, these have not yet been sufficiently incentivised and promoted by the regulatory authorities. Testing at a small number of locations in Germany is limited to "**first mover**" initiatives by innovative distribution system operators, such as the "**AmpaCity**" project in Essen, or "**SuperLink**" in Munich. In order to maintain Germany's technological lead in the long term, the regulatory course must be set for the validation of the next generation of superconducting cables.

Breaking down barriers

Electricity grid technologies are currently one of the **least innovative sectors**. This is partly due to **regulatory hurdles**, high investment costs, infrastructure complexity and risk aversion. However, the transformation of the electricity system requires a higher level of innovation and a broadening of the technological toolkit of grid operators.

Additional **regulatory instruments** that transfer innovations from the laboratory stage to a real, large-scale application are essential to bring future technologies to market maturity. Examples of this would be a targeted orientation of the planned **Real-World Laboratory Act** and an **innovation budget** in incentive regulation. This is the only way to trigger the necessary investments in innovative new cable technologies such as superconductors and make the grid fit for the future.