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Impact of batteries on electricity security and renewable energy expansion in Germany

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As renewable energies with low marginal generation costs expand in the power mix, they exert a downward pressure on wholesale prices for electricity — displacing conventional and more expensive fossil fuel power generation[1] (from coal, natural gas, fuel gas and oil). This increases the risk of experiencing mismatches in electricity supply and demand.[2] A key factor for securing electricity supply while enabling renewable energy expansion is, therefore, the development of flexible, sustainable technologies for both short- and long-term electricity storage. This study explores the impact of battery subsidies on renewable energy expansion and supply security in Germany.

As the generation capacity of renewable forms of energy — such as onshore wind power — expands, this increases the likelihood of the occurrence of lower (and sometimes even negative) prices of electricity in wholesale markets[3]. This mainly affects conventional facilities, with many power plants seeing their revenues and profitability reduced; and increases the risk of shutdowns for economic reasons. As a result, there is a need for greater flexibility to enable the necessary increase of renewable generation while ensuring a stable electricity supply.

Innovative electricity storage solutions are needed to ensure that renewable energy can expand without overly increasing (balancing) system costs and security of supply risks. This study explores the impact of large-scale battery systems on energy supply and expansion in Germany, a leading country in the transition towards renewable energy systems. The researchers consider how multiple energy and energy storage systems interact and identify optimal battery capacity depending on excess electricity demand. They also develop an electricity market model to simulate batteries as a) an economic-driven investment option and b) a government-subsidised option (where use of batteries is subsidised in the event of insufficient electricity supply).

The researchers present policy scenarios based upon four factors: the amount of renewable energy produced, the batteries' charging and discharging volume (battery energy), total carbon dioxide (CO_2) emissions, and the subsidies and external costs required to ensure security of supply. They develop six

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policy scenarios in which batteries are used and subsidised in various ways and compare these against a reference scenario of a free market environment (with all investments made by private investors).

The six scenarios vary in how electricity is traded (from a common electricity market design to a renewable energy adaptation market design[4]); how insufficient supply is dealt with (from use of batteries and supplementary renewable or conventional plants; to a fixed feed-in tariff (FIT) mechanism which pays renewable energy producers fixed prices for each unit of energy produced and added to the grid); and how conventional power, renewable energy and batteries are treated (with each, or a combination, of these remaining either in the free market or receiving differing levels of subsidies).

The reference policy scenario shows that, despite technological innovation bringing substantial cost reductions in batteries in recent years, battery investment is currently not profitable for private investors in a liberalised market environment. However, the varying policy scenarios demonstrate that, by subsidising investments in batteries, governments could ensure a secure electricity supply while also supporting renewable energy expansion. While the reference scenario cannot assure security of supply, all six subsidised policy scenarios are capable of this.

Assessing the results of their scenarios, the researchers posit that the most renewable energy is produced without a fixed price per unit of electricity produced without fixed feed-in tariffs (FIT), and the least when a FIT mechanism is applied (although expansion is more stable in the latter case). FIT mechanisms also lead to higher CO_2 emissions, because renewable energy production expands gradually and more conventional plants, therefore, remain in the market. A higher amount of renewable energy production on the free market, however, leads to market conditions that require heavy subsidies for both batteries and supplementary power plants (the type of power plant depends on the policy scenario).This is because conventional plants are more quickly driven out of the market, resulting in greater energy instability and insufficient supply). On the other hand, scenarios outside of the free market allow conventional plants to be successively phased out and decommissioned more sustainably, leading to a more stable expansion of renewable energy production, and lower subsidies for batteries.[5]

When comparing their simulations to similar policy scenarios that do not adopt batteries, the researchers find that the total sum of government subsidies and external costs is up to 36% lower when utilising batteries. The researchers conclude that government subsidies for batteries might be an economically efficient policy scenario for countries to simultaneously guarantee ongoing renewable energy expansion and an uninterrupted electricity supply.

Impact of batteries on electricity security and renewable energy expansion in Germany (Continued)

1. The higher costs of fossil-fuel generation are also in part due to the EU Emissions Trading System, which caps the amount of certain greenhouse gases that an energy production system can release in order to combat climate change and reduce emissions, and obliges these plants to pay allowances for emissions resulting from the process used to generate the electricity.

2. Managing energy supply to sufficiently meet demand has traditionally been achieved using flexible generation from fossil-fuel power plants.

3. Currently, most renewable energy producers participate in support schemes that guarantee their revenues (feed-in tariffs). This, combined with their negligible marginal costs of production, provides producers with an economic incentive to sell all the electricity they produce (irrespective of the prices set by supply and demand in wholesale markets).

4. Renewable energy adaptation market design: a market design in which electricity prices and plant profitability are dependent on the ability of the complex of conventional power plants to optimally react to changes in residual load.

5. The circumstance requiring the lowest government subsidies is the 'standard policy scenario', totalling around €2.3 billion. These subsidies account for the FIT mechanism that is applied for RE in this scenario — and because this mechanism leads to a slower expansion of RE, compared to free market conditions, the electricity prices in the market are at a higher level, which means that no further subsidies for batteries or supplementary gas power plants are required.