

BLACKOUT

E-MOBILITY PUTS
PRESSURE ON
GRID OPERATORS

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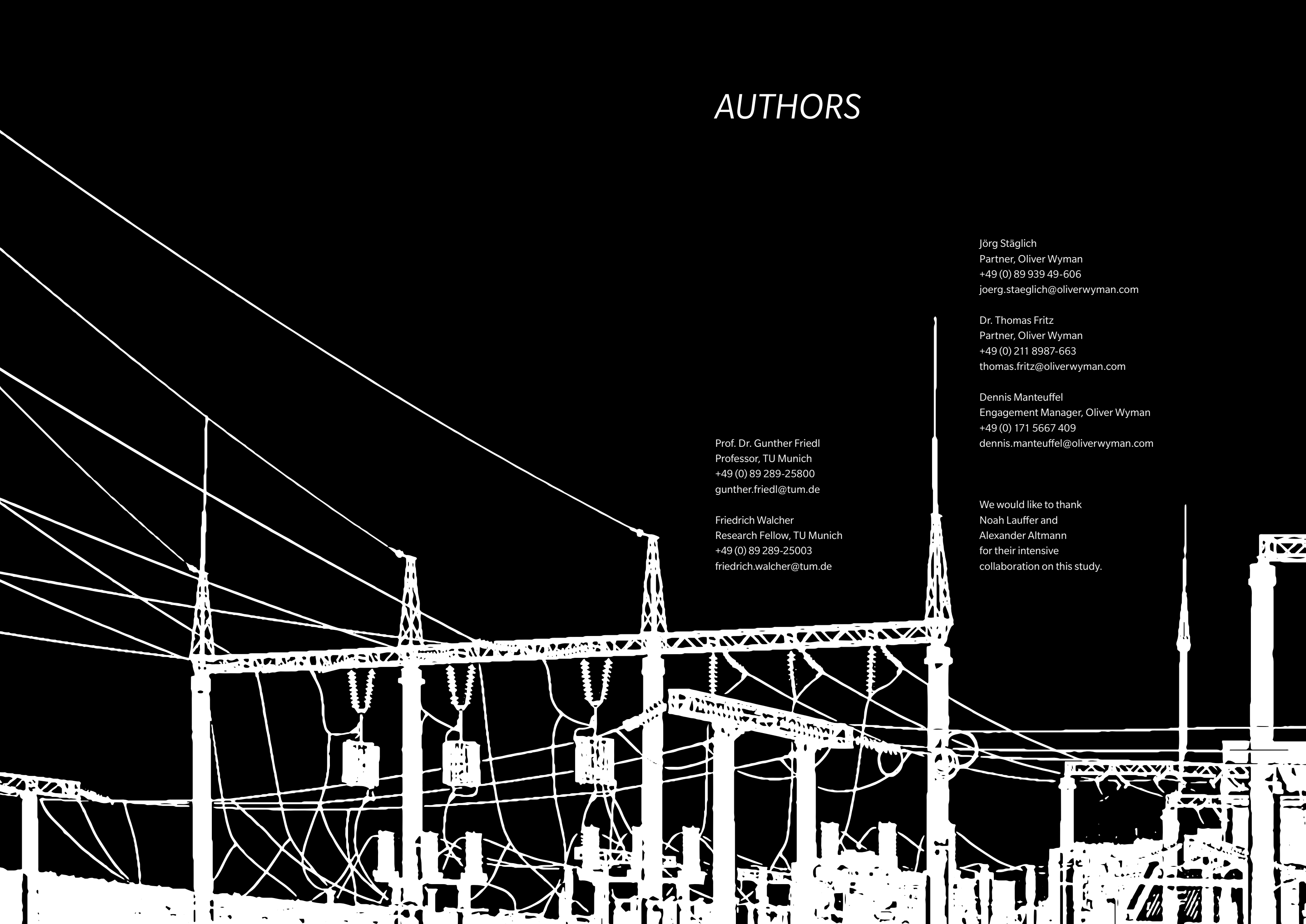
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GRID OPERATORS SHOULD PREPARE NOW FOR THE CHALLENGE OF E-MOBILITY

Within the current regulatory framework, more than one in three cars on German roads will run on electricity by 2035¹. This presents enormous challenges for Germany's power supply, since the low-voltage level of the German power grid is not designed for such a large number of e-cars. As a result, widespread blackouts may occur when e-cars account for as little as 30 percent of automobiles on the road. Unless preventive action is taken, this situation can be expected by 2032. In some cases, power supply bottlenecks will occur as early as five to ten years from now, especially in suburban areas with a strong affinity for electromobility.

To avoid blackouts, as much as eleven billion euros will need to be invested in grid expansion if 50 percent of the automobiles are electrified, as is expected over the long term. With the long lead time required for grid expansion, it is urgent to act now for the coming challenges.

At the same time, there is a highly economical, attractive alternative to conventional grid expansion: the smart transition to flexible charging.

Benefits of the flexibility transition:

- If only half the e-car owners participated in flexible charging for their vehicles, an electromobility quota of no more than 50 percent could be integrated into the current low-voltage grid.
- Even if participation were subsidized at a rate of 100 euros per user during the first few years, the transition to flexible charging would cost less than investing in grid expansion.
- If flexible charging of e-cars caught on, it could become entirely unnecessary to expand the power grid.

For these reasons, intelligent control of the charging processes is an effective way to reduce the need for grid expansion. First, however, appropriate regulatory requirements must be established so that grid operators can control the charging processes locally.

Decentralized power generation and storage could offer another possibility. As things currently stand, however, this alone is not sufficient to avoid conventional grid expansion.

¹ Oliver Wyman analysis, "E-Mobilität 2035," July 2017

ELECTROMOBILITY: CHALLENGES FOR THE POWER GRID

Electromobility is becoming more and more important in light of climate protection, the increasing scarcity of fossil fuels, and new mobility concepts. Before electromobility can become broadly available, however, a wide range of challenges must be overcome. They include increasing the vehicle range, expanding the charging infrastructure, tackling the high purchase and development costs of e-cars, and lowering the CO₂ balance in the energy mix.

Up to now, relatively little attention has been paid to one crucial challenge in this context: What impact will increasing electromobility have on the German power grid? A stable power supply is essential to a successful transition to electromobility.

The scenario:

Because most electric cars are charged at home, the potential bottlenecks in the German power grid involve, in particular, the local grids integrated into the low-voltage grid. A local grid generally supplies around 120 households. In principle, an electric car begins charging as soon as it is connected to the power supply. As a result, a critical peak load arises especially in the evening, when the electric car owners come home and connect their vehicles to the charging stations. If a large number of cars are connected at the same time, a bottleneck would occur in the local grid because it is not designed for this additional load. That creates the danger of greatly exceeding the maximum local grid capacity and causing a power outage.

High voltage: 220 to 380 kilovolts
Conventional power plants, hydroelectric power plants, nuclear power plants,
coal-fired power plants, offshore wind farms, power transports

High voltage: 110 kilovolts
Wind farms, photovoltaic power plants, heavy industry,
hydroelectric power plants, gas-fired power plants

Medium voltage: 6 to 30 kilovolts
Wind turbines, large photovoltaic systems,
industry/businesses, energy stores, solar farms, wind farms

Low-voltage: 230 to 400 volts
Small photovoltaic systems, homes/small businesses,
energy stores, heat pumps, solar plants,
CHP plants, electromobility

SUPPLY DEPENDABILITY IS IN JEOPARDY

Supply dependability is measured in loss of load hours. According to the VDE/FNN failure statistics, the figure for 2016 in Germany was about 12 minutes. Any upward deviation from this figure causes supply dependability to deteriorate.

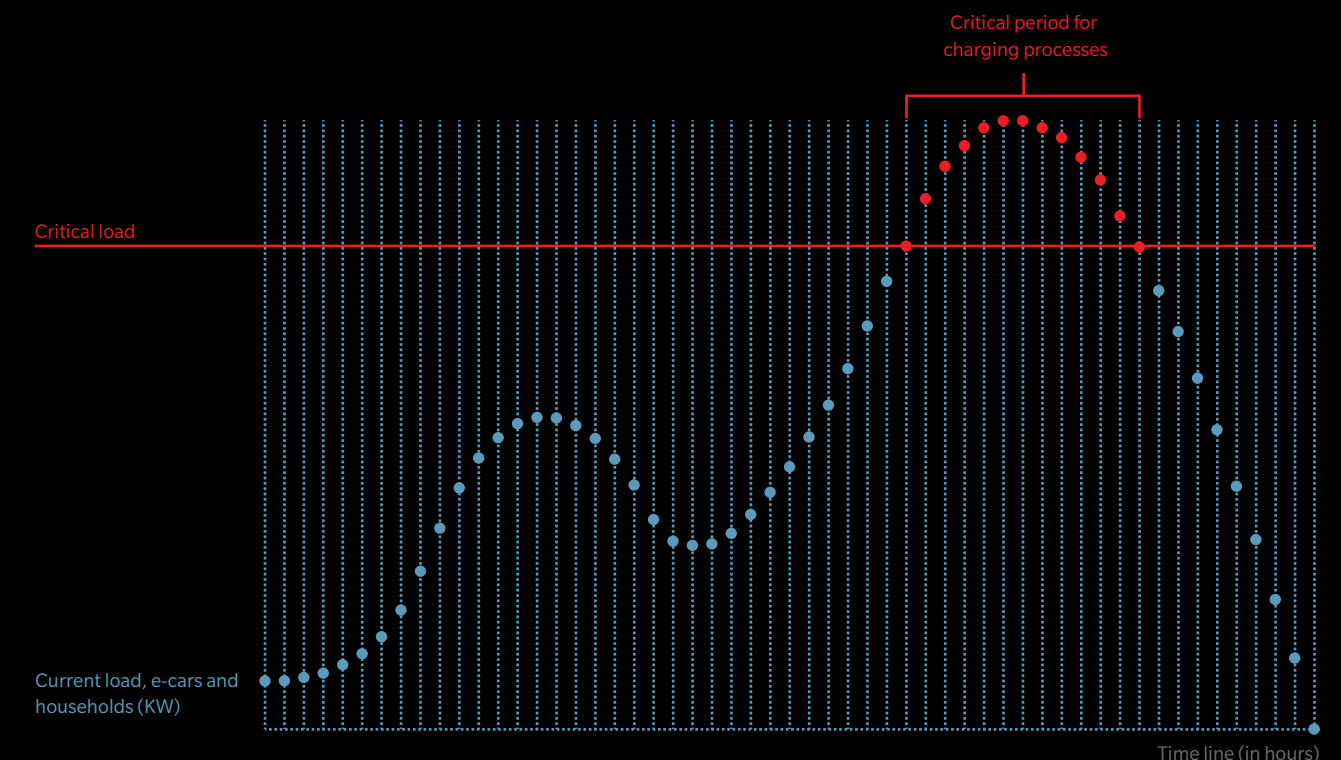
In order for a distribution grid operator to prepare for an increase in electromobility usage in Germany, decision-makers should address three questions in particular:

- How many electric vehicles can be integrated into an existing local grid?
- At what point do supply bottlenecks occur with existing capacities?
- What can be done to prepare a local grid to meet the challenges of e-mobility?

These key questions will be answered below with the aid of a probabilistic load simulation model developed specifically for this purpose.

Different input parameters have been integrated into the model, including the standard load profile for households and local elements, such as the number and capacity of photovoltaic systems as well as their charging and discharging power. Various parameters for electric vehicles were also incorporated into the model, including the car category, the distribution of charging variants, road performance, average fuel consumption, arrival and departure times, and the utilization rate.

MODEL: SIMULATION OF A LOCAL GRID NODE



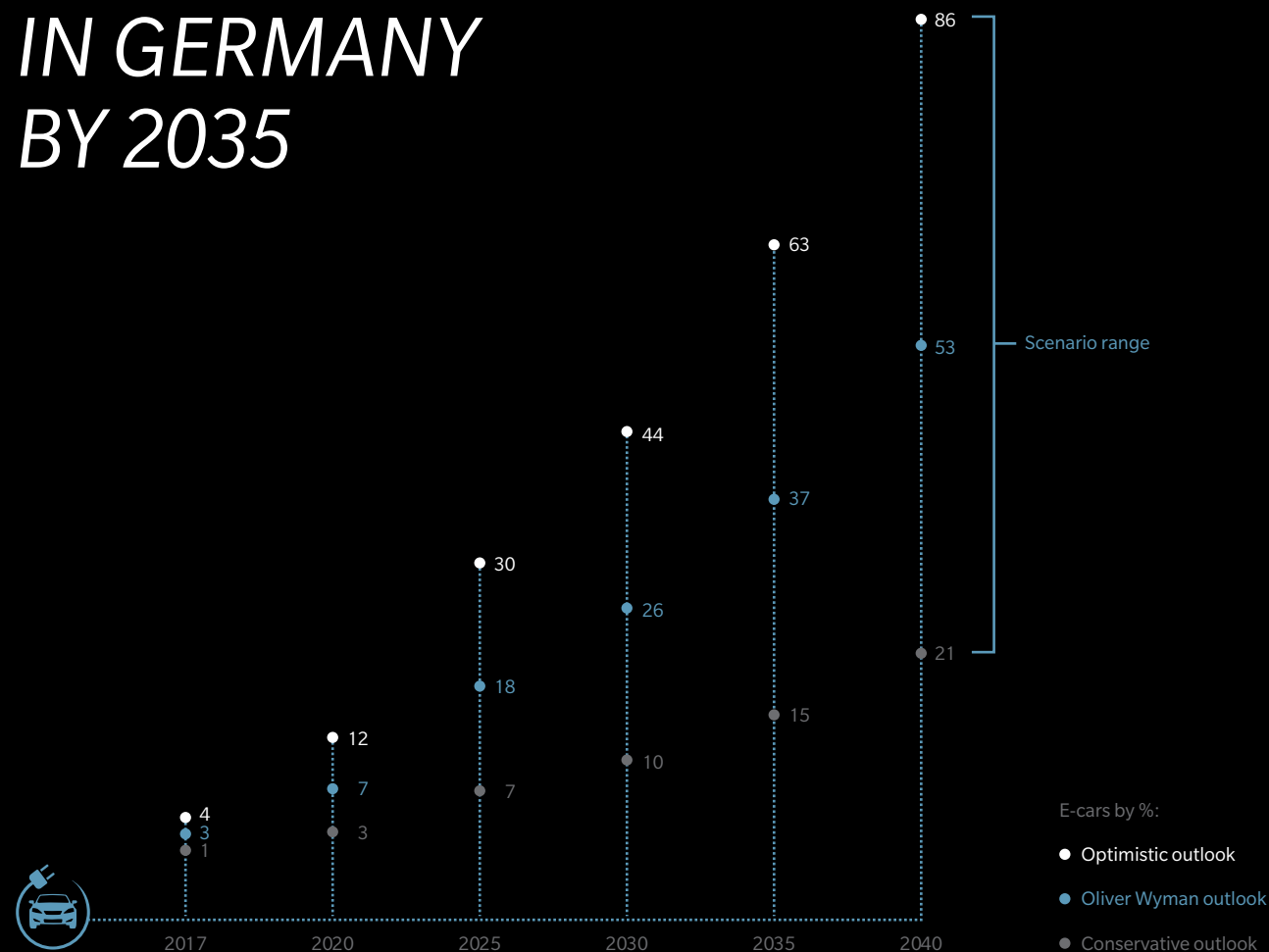
The model maps a local grid node through a modular structure, in which the household and electric vehicle loads are simulated. The model also can be expanded by integrating decentralized power generators and energy stores and by transitioning to flexible charging for electric vehicles.

The model is used to analyze the number of times the local grid capacity is exceeded per

year, depending on different percentages of e-cars among total automobiles. The loss of load hours is calculated on this basis.

To obtain the most realistic data, the elements contained in the model are varied using a Monte Carlo simulation. The large number of parameters makes it possible to model and simulate individual scenarios.

37% E-CARS IN GERMANY BY 2035



Electric vehicles are increasingly popular in Germany, especially because they meet the citizens' growing demand for cleaner and more climate-friendly mobility. In addition, automakers can reach their CO₂ targets only with a relevant share of zero-emission vehicles.

In terms of forecasts on further electro-mobility growth, however, the latest studies show significant differences of more than 60 percent.

Oliver Wyman considers an electro-mobility share of 37 percent by 2035 to be realistic². At the same time, the scenarios take into account a more conservative forecast (a 15 percent electromobility share) as well as a more optimistic assessment (63 percent).

Based on these forecasts, the model simulation analyzed the point at which overloads occur in the local grid and blackouts become highly probable.

WIDESPREAD BLACKOUTS IN 2032 AND BEYOND

Supply dependability is measured in loss of load hours. The annual average in Germany is about 12 minutes. Any deviation from this figure causes supply dependability to deteriorate.



Under the conditions of the existing grid structures and regulations regarding them, widespread overloads in the low-voltage grid will occur with 95 percent probability, starting when electromobility makes up 30 percent of cars. Depending on the forecast used as a basis, the 30 percent figure will be reached between 2025 and 2040. Based on the Oliver Wyman study "E-Mobilität 2035", it can be assumed that this situation will occur as of 2032 if the regulatory framework remains unchanged.

Due to local differences – such as in income or housing, for instance – some regions of Germany will reach the electromobility mark

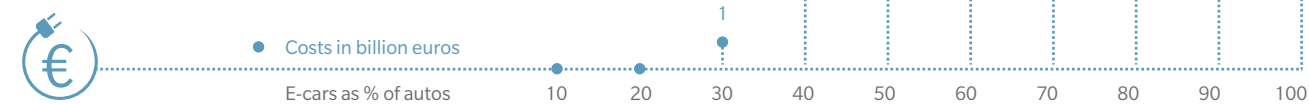
of 30 percent much sooner than others. These local e-mobility hot spots will push grid operators to take anticipatory measures even today in order to be prepared for noticeably higher electromobility usage well in advance of 2032. With a local grid size of 120 households, as few as 36 electric cars are already enough to overload a grid. Grid operators should focus primarily on suburban areas where electromobility is more popular.

Consequently, there is an urgent need for the stakeholders to take action, since expanding the grid will require substantial lead times.

² Oliver Wyman analysis „E-Mobilität 2035“, 2017

THE HIGH COST OF LOCAL GRID EXPANSION

As electromobility increases, the cost of grid expansion shoots up. A 50 percent level of electrification requires 11 billion euros to be invested; at a 100-percent level of electrification, this figure rises to 26 billion euros.



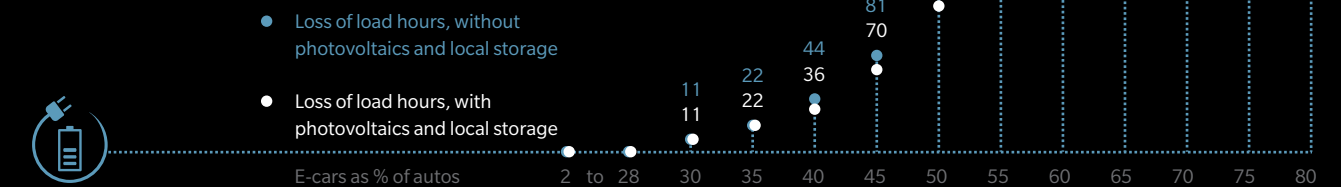
To avoid overloading their grids, distribution grid operators must prepare themselves for e-mobility expansion. This means that grid expansion becomes necessary when the electromobility reaches a limit value of 30 percent of passenger cars. At 50 percent, an additional cost of around eleven billion euros must be invested. In light of the illustrated scenario, operators must begin expanding their grids without delay and complete the expansion by 2032. If they fail

to do this, widespread blackouts are likely to occur in the near future.

The relatively high cost of grid expansion raises the question of whether there are economically sensible alternatives. One possibility could be to use existing local elements such as photovoltaic systems and decentralized energy stores. Another option is the smart transition to flexible charging.

DECENTRALIZED POWER GENERATION AND STORAGE ARE NOT THE ONLY SOLUTIONS

Decentralized storage and photovoltaic systems can be used as buffers to relieve the load on local grid transformers and reduce overloads at peak times. However, their power depends on weather conditions and time of year – and they are not the only alternatives to grid expansion.

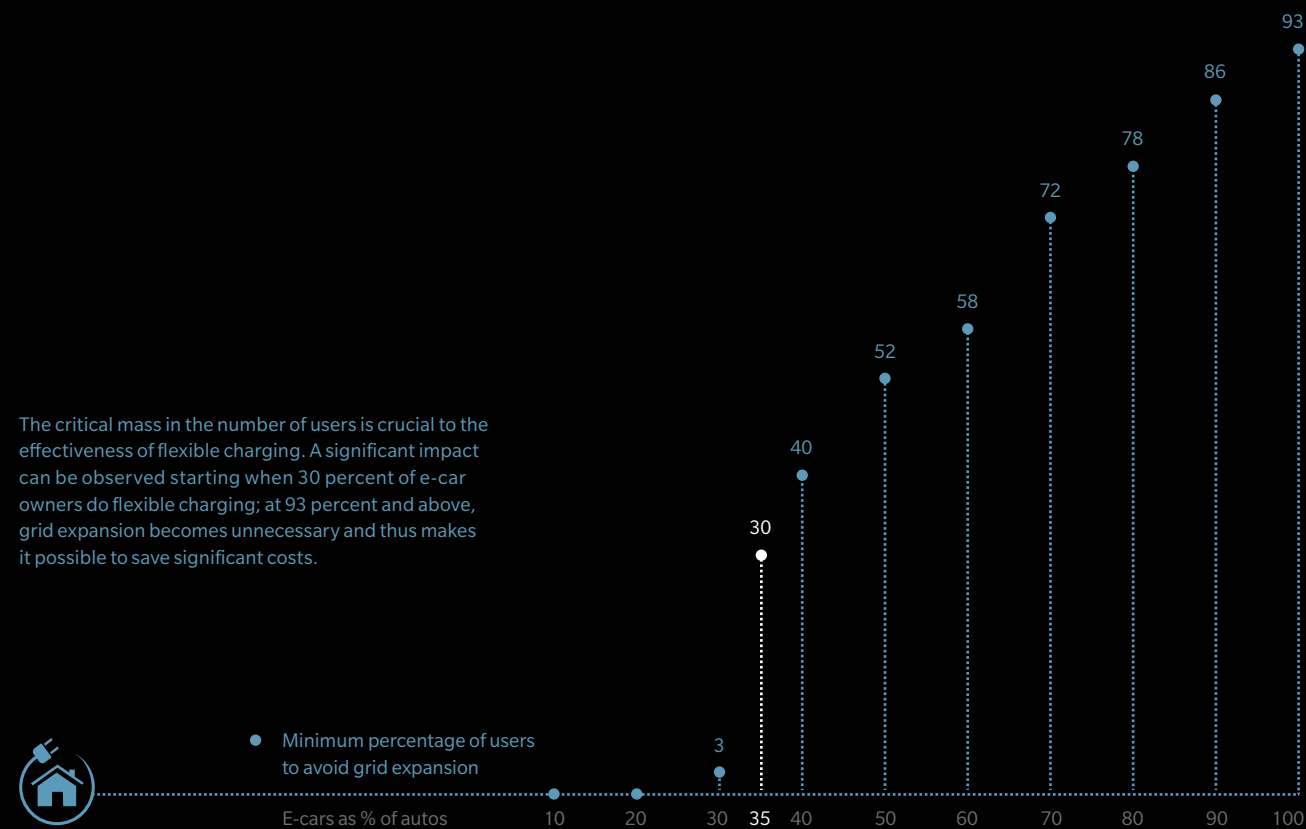


The energy transition, government feed-in tariffs and the increasing desire of many households for grid independence have led to a widespread use of photovoltaic systems and ultimately also decentralized energy storage systems in Germany. From a technological perspective, the combination of decentralized energy storage and photovoltaic systems can be used as a buffer to avoid overloading the grid at critical points in time.

The disadvantage is that this buffer is most effective in summer and not very effective during winter because of weather conditions and seasonal volatility. As a result, decentralized power generation and storage cannot be the sole alternative to conventional grid expansion.

THE TRANSITION TO FLEXIBLE CHARGING FOR BALANCING OUT THE LOAD

The critical mass in the number of users is crucial to the effectiveness of flexible charging. A significant impact can be observed starting when 30 percent of e-car owners do flexible charging; at 93 percent and above, grid expansion becomes unnecessary and thus makes it possible to save significant costs.



The smart transition to flexible charging of electric vehicles has proved to be a practicable and economically sensible alternative to grid expansion. The charging process is generally so short, compared with the time the vehicle is idle overnight, that the e-car can be connected to the power supply for most of the night without being actively charged. Most charging processes therefore have a certain time flexibility. They do not have to start at the very moment the car is connected to the outlet. Instead, the charging process can begin later in the night – that is, outside peak load periods – without electric car users having to do without a full charge the next day.

By transitioning to flexible charging times and power levels, a local grid operator can shift the charging load of an electric car, thereby reducing the cumulative load peak and smoothing out the load curve as a whole.



To assess the benefits of flexible charging, Oliver Wyman analyzed scenarios with different numbers of flexible-charging users per local grid node.

The results:

The critical peak load at the local grid node can be significantly reduced if as few as 30 percent of the e-car users participate in flexible charging. If half of them participate, the limit value increases to 50 percent without grid expansion. In this case, one in two cars can be an e-car without causing bottlenecks in the distribution grid during the usual charging periods. If the grid operators win over at least 92.5 percent of e-vehicle owners to flexible charging, there is no longer any need to expand the grid, even if 100 percent of e-cars were charged this way.

If a grid operator persuades enough users to transition to flexible charging, this option becomes an alternative to conventional grid expansion since the technical implementation of this concept can be largely done with software solutions.

E-car owners may need an incentive to participate in flexible charging. A sample calculation: A subsidy of 100 euros per year to each user would cost about 4.6 billion euros by 2039 (cumulatively) with an e-car quota of 50 percent. Compared with the cost of grid expansion (11 billion euros), this would mean a savings potential of about 6.4 billion euros.



TRANSITION TO FLEXIBLE CHARGING COULD AVOID E-MOBILITY BLACKOUTS

With the growing trend toward electromobility, grid operators must act now to prepare their local grids for greater simultaneous connections to the power supply. If they fail to do this, widespread supply bottlenecks will occur as early as 2032. In some cases – such as in suburban areas with a higher affinity for electromobility and a corresponding jump in e-cars on a local grid node – these bottlenecks could occur five to ten years from now.

Different options exist for avoiding an e-mobility blackout. The transition to flexible charging is the most economically attractive alternative to grid expansion, since it has the potential to dramatically reduce the

extent of the grid expansion and thus save an enormous amount of money. The biggest challenge for grid operators will be to persuade a sufficiently large number of e-car owners to participate by way of subsidies.

An appropriate regulatory framework is required to implement this alternative. Regulators must enable grid operators to control charging processes locally.

The system also should be designed with an incentive for distribution grid operators themselves to switch to flexible charging instead of implementing a further grid expansion.

ABOUT OLIVER WYMAN

Oliver Wyman is a global leader in management consulting. With offices in 50+ cities across nearly 30 countries, Oliver Wyman combines deep industry knowledge with specialized expertise in strategy, operations, risk management, and organization transformation. The firm has more than 4,700 professionals around the world who help clients optimize their business, improve their operations and risk profile, and accelerate their organizational performance to seize the most attractive opportunities. Oliver Wyman is a wholly owned subsidiary of Marsh & McLennan Companies [NYSE: MMC]. For more information, visit www.oliverwyman.com. Follow Oliver Wyman on **Twitter @OliverWyman**.

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