VDE Discussion Paper

More resilience for power and communication networks

How do we deal with increasing interdependencies?

Executive Summary

Electric power and digital communication are known to be essential prerequisites for our daily lives today. Almost permanently available power and communication networks are crucial for the "All Electric Society", and their significance will continue to increase over the next years. It is therefore important to determine what level of resilience to disruption and failure we as a society can and want to afford in relation to these critical infrastructures. This paper specifically addresses the interdependencies between electricity and communication networks, which will increase as the energy transition progresses, and provides targeted recommendations for action.

Challenge

Climate change is forcing the widespread use of volatile renewable energies. At the same time, it is forcing the decentralization of our electrical energy supply, which can only be achieved through the extensive digitalization of producers, storage systems and consumers. Digitalization, in turn – as in all other areas of our economy and society – depends on stable communication links, which require a reliable stable power supply. In addition to grid-specific communication networks, public networks will increasingly be used to operate power grids, e.g. to connect households and small businesses so that photovoltaic production, storage systems and large consumers (e.g. charging stations or heat pumps) can be controlled in a network-oriented manner if required. As a result of climate change, we must also expect an increase in extreme weather events, which can pose a threat to power and communication networks. Digitalization also brings its own risks, such as massive cyberattacks.

This raises the question of how resilient our energy and communications networks are to current and, more importantly, future threats, given their increasing interdependence. Can they adequately absorb and recover from changes and disruptions in the other infrastructure, or should we, on the contrary, expect failures to propagate from the power grid to the communications network and vice versa?

Method

VDE investigated this question with a cross-industry working group made up of experts from its specialist societies for energy technology and information technology (ETG and ITG). This was based on current and expected technical developments in power and communications networks. Typical operating scenarios were analyzed, both in normal operation and in the event of a disaster. From this, threats to the resilience of the networks as well as other questions were derived and initial approaches to solutions were outlined. The findings and recommendations are aimed at experts in industry, authorities and politics help them understand the cross-sector dependencies and thus contribute to the resilience of our future electricity and communication networks in normal operation and in the event of a disaster.

VDE Association for Electrical, Electronic & Information Technologies
Merianstrasse 28
63069 Offenbach am Main
Germany
Tel. +49 69 6308-0
service@vde.com
www.vde.com

VDE

Main Results

Six operating scenarios were developed:

- Power grids: Normal operation including possible technical disruptions in current and future networks
- Power grids: Grid operation in the event of a disaster
- Telecommunications networks: Power supply of public telecommunications networks during normal operation and in the event of technical disruptions due to power failure
- Telecommunications networks: Disasters and massive destruction of the telecommunications infrastructure
- Disaster: Large-scale cyberattack on power networks (resulting in a widespread failure of public telecommunications networks)
- Disaster: Major physical destruction of infrastructure (such as caused by massive flooding in the Ahr valley in western Germany in 2021)

From the analysis of the operational scenarios, several hypotheses can be put forward that show how a high level of resilience can be ensured in our future electricity and public communication networks. This requires answering relevant questions and implementing targeted solutions. Particularly in the telecommunications market with its strong infrastructure competition, responsibilities and financing must be clarified and, where necessary, the legal and regulatory framework must be adjusted.

- In the power grid, the energy transition brings along a change in the electrical energy supply from a synchronous generator-dominated to a converter-dominated network. This transition poses challenges, as for example the elimination of generators with large rotating flywheels and their contribution to system stability. But it also opens up new opportunities to increase the availability of power supply. In the long term, it will be possible to switch to controlled island network operation in the event of a fault using network-forming converters. This will also benefit the availability of public telecommunications access networks.
- Utilities can maintain stable power grid operations even in the event of disruptions to public telecommunications networks through their own communications networks, the critical infrastructure 450 MHz LTE private network in Germany and, if necessary, rented blackout-proof communications links.
- To meet the increasing communication needs of electrical distribution networks as the number of renewable, fluctuating generators and controllable loads increases, public telecommunications networks are increasingly being used for non-time-critical management functions and, in some cases, for stability-relevant functions. This may require increased availability of access networks in certain areas.
- The resilience of public communications services in the event of power failures will be enhanced by evolving network topologies, local renewable energy generation and, where necessary, more power backup in access networks, as well as through the systematic inclusion of all participants in the value creation process for telecommunications services. In addition, the users of the services must provide a sufficiently secure power supply for their end devices.
- The measures mentioned to improve the availability of electricity supply and public telecommunications services open up synergy potential for improving the resilience of electricity and communications for other critical infrastructures and for the population. This option is of high societal value, particularly in the event of disaster. Therefore, the second step is to take a comprehensive approach involving other stakeholders beyond the power grid and telecommunications network sectors.

Several questions need to be considered in detail. These include, for example, the systematic analysis of future communication requirements for power grid operations, the location-specific requirements of telecommunications networks for the supply of electricity and the effects of possible power outages on all those involved in the provision of telecommunications services. The possible propagation of errors across sector boundaries or the future requirements for cross-sector communication in regular operations must also be examined. Further questions arise when considering possible catastrophes. Not only the electricity and telecommunications network operators, but also other stakeholders such as public authorities or other critical infrastructures should be included here. Ultimately, it's about the question what level of resilience we as a society can and want to afford.

Areas of action with possible solutions can be categorized into technology and infrastructure, processes and procedures, as well as personnel and information. This discussion paper focusses on the future design of technology and infrastructure. On the part of public communications networks, for example, targeted expansions of grid-independent power supply in the access network (e.g. renewable energies with battery backup), virtualization of network functions, or use of network-inherent redundancies are possible. In the power grids, grid-forming converters in conjunction with decentralized storage and distributed renewable energy sources will in the long run enable the formation of temporary island networks in case of large-scale failures. When it comes to processes and procedures, a structured mutual exchange of information and, if necessary, joint planning of the operation of electricity and telecommunications networks should be established in order to avoid mutual influences as far as possible, or to be able to overcome them quickly in the event of disruptions. A coordinated, structured approach is particularly important in the event of major disruptions, e.g. large-scale cyberattacks or natural disasters. This requires experts from all sectors involved to understand the future interdependencies between the networks involved and to design their respective plans accordingly.

VDE therefore recommends to act in four dimensions:

- Awareness

  Given the recent increased awareness of the need for resilience, our power and communications networks in particular need to receive sufficient attention. The power grid, including the communication services required for its reliable operation, is particularly important as a foundation for all other infrastructures. In order to implement concrete measures, awareness must be raised that resilience initially incurs costs, but can pay off economically through avoided damage.

- Thinking and acting across sectors and industries

  Similar to how we have long thought about different energy networks in the context of sector coupling, we also have to come to a systemically common view of electricity networks and public communication services. Thinking and acting across sectors requires the relevant knowledge and skills of the specialists involved at operators, manufacturers and authorities, as well as appropriate training and further education.

- Consideration of the possibility of disasters

  In the context of possible disasters caused by climate change and other events, increased measures must be taken to ensure the resilience of our electricity and communications networks in an appropriate and graduated manner, taking into account technical developments and the risks to be expected in the future. Electricity and public telecommunications networks and other critical infrastructures should be “thought together” over a wide area.

- Systematic planning and implementation of measures

  Based on a systemic view, possible measures should be assessed, prioritized and then planned and implemented in terms of their effectiveness, urgency and technical and economic feasibility. This includes:

  - Short term: Identify the communication infrastructure's requirements for a secure power supply as well as the additional need for power failure-resilient communication, selectively expanding the independence of public communication networks from the public power supply (requires clarification of funding and responsibilities). Establish standardized interfaces and operating processes between power grid and public telecommunications network operations.

  - Medium -term: Plan the future required communication services for electricity networks and the power supply for public communication networks jointly by power utilities and telecommunications network operators to ensure the resilience of the entire system. Thereby create targeted synergetic benefits for other critical infrastructures and the population. Developing and establishing scenarios for disasters and establishing of according cross-sector procedures and exercises with the participation of all relevant stakeholders, also across federal states and national borders.

- Long term: Prepare for temporary island network operation of power grids in the event of a disruption through the use of grid-forming converters combined with decentralized storage and distributed renewable energy resources. Run research projects to analyze the future communication requirements (connections) in the overall system, identify risks and the need for action as well as opportunities and recommendations for action (technical, economic, regulatory). Establish mechanisms for cross-sectoral optimization, and implement infrastructural measures to increase resilience.

Today in Germany we have a highly reliable electricity supply and we can rely on public communications networks with good availability and extensive resilience to disruptions. The reliability of our networks must be constantly developed and secured. It must be ensured that all network operators comply with the corresponding minimum standards - this applies, for example, to large and small operators of electrical distribution networks as well as to competing operators of public communications networks. Only if we consciously address the identified and upcoming challenges together with the technological development of our networks and across sectors, will we continue to have a reliable power supply and stable public communication services in the future.

VDE, as the leading technology organization in Germany with in-depth knowledge of both electrical energy and information and communication technology, is available as a partner for experts in industry and authorities. This applies to support training and skill enhancement, cross-sector dialogue, and the standardization of interfaces, and also to active participation in shaping suitable operating procedures. VDE is also happy to support the political dialogue with neutral specialist information.

The VDE discussion paper is the result of the VDE ETG ITG joint working group "Resilient Networks". It is available (in German language) on: www.vde.com/etg or www.vde.com/itg

Authors

Sigurd Schuster (Nokia/Sigurd Schuster Management Consulting, coordination)
Michael Düser (Deutsche Telekom)
Christine Herr (Westenergie)
Manuel Ostertag (Westenergie)
Florian Steinke (TU Darmstadt)
Jürgen Tusch (Dr. Tusch Consulting)

Remarks

In compliance with VDE's positioning as a neutral, technical-scientific association, VDE studies reflect the common findings of the members of the respective working groups. The joint results were developed in a constructive dialogue, often from different positions. The studies therefore do not necessarily reflect the positions of the companies and institutions represented by their employees.

Issue: February 2024

www.vde.com