Over the next two decades, the energy transition and the growth of digitalisation will result in new risks to the electricity supply. A resilience strategy will be required to manage these risks and reliably prevent blackouts and their damaging impacts on society. The “Resilience of digitalised energy systems” working group of the Academies’ Project “Energy Systems of the Future” has identified the following points as the key pillars of any such strategy:

- **Digitalisation** should be actively shaped and promoted, since it offers the opportunity to efficiently and securely integrate decentralised electricity generation structures, electric mobility and new market players into the energy system.
- **Small players** in the energy supply market, actors from outside the energy supply sector (appliance manufacturers, platform operators, public communication network operators) and private households all have a growing influence on the security of the energy supply. They should therefore be more closely involved in efforts to strengthen resilience.
- New targets for cybercriminals and the electricity system’s greater reliance on information and communication technology could result in unforeseen or even unforeseeable incidents with the potential to pose a major threat. Grid operators must be able to manage these risks.
- Policymakers must endeavour to anticipate future developments in good time and ensure that the resilience strategy called for in this paper is continuously adapted. This will require systematic monitoring.
Digitalisation and growing complexity are resulting in new threats

A reliable electricity supply is indispensable in a modern industrialised society. Major blackouts – i.e. *lengthy and widespread power outages* – would almost instantly cause serious disruption to and potentially even the collapse of other critical infrastructure such as transport systems, the water supply and sewerage systems, the healthcare system, and information and communication systems.

**The energy transition is making the energy system more complex.** More and more electrical power is being produced by wind and solar systems, the output of which fluctuates depending on the weather, season and time of day. Demand for electricity to power electric vehicles and heat pumps is growing. Private households are now generating electricity with their own solar panels, while new market players with new business models are emerging alongside the traditional energy providers. Meanwhile, the large power plants that used to ensure a stable electricity supply are being decommissioned.

At the same time, the pace of *digitalisation* is accelerating rapidly. Connectivity, automation and the use of digital technology are all increasing – and not just in the electricity sector. Billions of devices – including everything from lights and fridges to industrial equipment – are now connected via the *Internet of Things*. Since these devices are also connected to the power grid, their combined effect can influence the stability of the electricity supply.

The growing role of information and communication technology (ICT) is key to ensuring a reliable and economically efficient energy supply – the energy transition cannot succeed without digitalisation. However, the increasing complexity of the energy supply also gives rise to new blackout risks:

1. The electricity supply can be destabilised if *several small electricity generators and consumers* are all switched on or off at the same time, either intentionally or by chance.

2. The electricity supply is becoming more vulnerable to *ICT failures*. One particularly problematic aspect is that some of the relevant ICT systems cannot be switched off in the event of a failure without seriously jeopardising the electricity supply.

3. The complex interactions between decentralised generation, market activity and changes in consumption make it *harder to predict* the system’s behaviour and could mean that *incidents unfold in complex new ways*.

4. **Uncertainty about future developments inhibits optimal system design.** A further challenge is that the speed of innovation in the ICT sector is difficult to reconcile with investment cycles in the electricity sector, which tend to be several decades long.
A resilience strategy for unforeseen and unforeseeable risks

The changes in the energy system and the growing impact of digitalisation are heightening uncertainty about future developments. As a result, it is becoming increasingly difficult to calculate the probability of known or expected events such as hacker attacks. While conventional risk analysis techniques employing this approach have until now formed the basis of a robust system, they are no longer enough. The grid operators responsible for the system’s overall security will also have to come to terms with a far more uncertain and unpredictable future. It will be increasingly important for them to be capable of responding to and coping with unforeseen or unforeseeable events and rapidly restoring the system to normal operation, even in the event of a blackout. Resilience is a tried-and-tested concept for managing this kind of situation. Resilience means that the system can absorb the impacts of an incident without collapsing, and then rapidly return to normal operation. Depending on the circumstances, it may be necessary to accept a short-term drop in supply quality in the worst-case scenario (see Figure 1).

A resilience strategy calls for a portfolio of measures. These include the exhaustive identification of weaknesses and risks, measures to support the system’s robustness, resilience and adaptability, and measures to promote learning and improve the system, including cost-effective emergency response planning.

The working group has identified 15 policy options (see next page) that can form the building blocks of a resilience strategy for preventing major blackouts. The policy options were chosen to address the areas where action is required today in order to tackle the new risks that will emerge over a longer-term timeframe between now and 2040. It will be vital for the resilience strategy to keep pace with the rapid progress of digitalisation and the energy transition in order to fully harness the potential for an efficient, secure and sustainable energy supply and successfully manage blackout risks in a digitalised world.
Options for reducing blackout risks

The following measures have been identified as the building blocks of a comprehensive resilience strategy for a digitalised energy system. The measures have been grouped into different policy areas:

Policy options:
Understanding and managing the interactions between ICT and energy systems

- PO 1. Analyse interdependencies between the electricity supply and communication networks in order to minimise the risk of cascading failures.
- PO 2. Establish rules for resilient communication networks by stipulating higher redundancy and blackout proofing standards.
- PO 3. Encourage the relevant actors to integrate the operation of ICT systems and electricity grids with a view to incorporating ICT monitoring into grid operating systems and enabling integrated situational awareness.

Policy options:
Systemic development of cybersecurity

- PO 4. Introduce cybersecurity standards for all actors relevant to blackouts, including small grid operators, actors from other industries, and behind-the-meter devices.
- PO 5. Define measures for addressing security vulnerabilities in order to counter vulnerabilities caused by human error in security management, software bugs or government-mandated backdoors.

Policy options:
Strengthening the contribution of grid operators and grid users to technology resilience

- PO 6. Accelerate digitalisation of electricity grids, ensuring that small grid operators also have the necessary technological resources.
- PO 7. Formulate guidelines for enabling resilience through decentralised structures. Individual sections of the grid that are able to operate in island mode can temporarily maintain the local electricity supply during a blackout and help to restore the overall supply.
All the relevant actors will need to do their bit to strengthen resilience if we are to maintain the highly reliable electricity supply that we are accustomed to. Policymakers can create the necessary framework by establishing an appropriate resilience strategy.
The Academies’ Project “Energy Systems of the Future”

The Position Paper The resilience of digitalised energy systems. Options for reducing blackout risks evolved within the framework of the Academies’ Project “Energy Systems of the Future”. In interdisciplinary working groups, about 100 experts are working on different courses of action for the pathway to an environmentally sustainable, safe and affordable energy supply.

Participants in the working group “Resilience of digitalised energy systems”

**Members:** Dr. Christoph Mayer (Lead, OFFIS), Prof. Dr. Gert Brunekreeft (Lead, Jacobs University Bremen), Dr. Marius Buchmann (Jacobs University), Mathias Dalheimer Fraunhofer ITWM, Dr. Volker Distelrath (Siemens AG), Prof. Dr. Bernd Hirschl (IÖW/BTU), Prof. Dr. Jochen Kreusel (Hitachi ABB Power Grids), Prof. Dr. Wolfgang Kröger (ETH Zürich), Prof. Dr. Sebastian Lehnhoff (OFFIS), Dr. Till Luhmann (BTC AG), Prof. Dr. Jannika Mattes (University Oldenburg), Prof. Dr. Ellen Matthies (University Magdeburg), Dr. Philipp Werdelmann (Westnetz GmbH), Prof. Dr.-Ing. Christof Wittwer (Fraunhofer ISE)

**Scientific coordinators:** Dr. Achim Eberspächer (acatech), Dr. Berit Erlach (acatech), Katharina Bähr (acatech), Dr. Marita Blank-Babazadeh (OFFIS), Sanja Stark (OFFIS)

**Contact:**

Dr. Ulrich Glotzbach  
Head of Project Office “Energy Systems of the Future”  
Pariser Platz 4a, 10117 Berlin, Germany  
phone: +49 30 2 06 79 57 - 0  e-mail: glotzbach@acatech.de  
web: energiesysteme-zukunft.de/en