OFFICE OF TECHNOLOGY ASSESSMENT
AT THE GERMAN BUNDESTAG

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What Happens During a Blackout

Consequences of a Prolonged and Wide-ranging Power Outage

Final Report

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WHAT HAPPENS DURING A BLACKOUT

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The Office of Technology Assessment at the German Bundestag is an independent scientific institution created with the objective of advising the German Bundestag and its Committees on matters relating to research and technology.

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TAB's task is to design and implement technology assessment (TA) projects and to monitor and analyse important scientific and technological trends and the associated social developments (Monitoring, Future- and Innovation Reports, Policy-Benchmarking Reports).

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WHAT HAPPENS DURING A BLACKOUT

CONSEQUENCES OF A PROLONGED AND WIDE-RANGING POWER OUTAGE

Report for the Committee on Education, Research and Technology Assessment

OFFICE OF TECHNOLOGY ASSESSMENT
AT THE GERMAN BUNDESTAG

NOTE

The orientation and content of this report cannot be taken as indicating the position of the German Bundestag or its Committees.

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THE COMMITTEE' S PREFACE

Infrastructures such as a reliable energy supply, functioning water-supply and wastewater-disposal systems, efficient modes of transport and transport routes and also information technology and telecommunications technology that can be accessed at all times represent the lifeblood of high-technology industrialised nations. The Committee on Education, Research and Technology Assessment therefore commissioned the Office of Technology Assessment at the German Bundestag (TAB) to investigate the possible effects of a prolonged and widespread power blackout on highly critical infrastructures such as drinking water, wastewater, information and communications systems, financial services and health services, especially against a backdrop where the blackout has a cascading effect spanning state and national boundaries.

In Germany, several recent natural disasters and technical malfunctions (Elbe and Oder floods in 2002/2005, power blackout in the Münsterland in 2005, the Kyrill storm in 2007) have highlighted the population's dependence on such (critical) infrastructures. Supply bottlenecks, public safety problems and disruptions to road and rail transport have revealed the vulnerability of modern societies and made extreme demands on health, emergency and rescue services.

Since almost all critical infrastructures rely heavily on a power supply, a scenario of a widespread and prolonged power blackout involving massive disruption to supplies, economic damage and risks to public safety is a very serious matter. In 2004 the National Crisis Management Exercise (LÜKEX) highlighted the problematic consequences and chains of consequences and also the enormous difficulties faced by federal structures in managing such a crisis and threat situation that strikes without any advance warning.

As far as can be seen, however, the possible consequences of such an event have not yet been subject to an in-depth, systematic analysis in the literature or in official documents.

The analyses conducted by the TAB reveal that the consequences of such a power blackout could at least be akin to a national disaster. All internal and external civil protection forces would need to be mobilised in order to at least mitigate the effects.

The TAB report indicates how the resilience of critical infrastructures could be strengthened and how possible courses of action within the national system for disaster management could be improved. The report thus makes a valuable contribution towards heightening awareness of this issue within industry and society and offers the committees of the German Bundestag a sound basis for further consideration.

Berlin, 7 April 2011

The Committee on Education, Research and Technology Assessment

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INHALT

SUMMARY

Modern, high-technology societies based on the division of labour have an advanced, highly complex network of »critical infrastructures« that supply the population with vital/essential goods and services. These critical infrastructures include information technology and telecommunications, transport and traffic, energy supply and health care system. The internal complexity of and high levels of interdependence between these infrastructures make them extremely vulnerable. In the past decade in particular, terrorist attacks, natural disasters and extremely grave accidents have demonstrated the far-reaching consequences that damage to or failure of critical infrastructures can inflict on our social system as a whole.

With electrically operated devices now virtually omnipresent in our living environment and our world of work, the consequences of a prolonged and widespread power blackout would combine to produce an extremely serious damage situation. All critical infrastructures would be affected and it would be almost impossible to prevent a collapse of society as a whole. Yet despite this potential for threat and disaster, society exhibits limited awareness of the risks involved.

Following a decision by the Committee on Education, Research and Technology Assessment, the Office of Technology Assessment at the German Bundestag (TAB) was commissioned to undertake a systematic analysis of the consequences of a prolonged and widespread power blackout. The study was also to examine the capabilities and limits of the national disaster management system for dealing with such a major damage situation.

DISASTER MANAGEMENT IN GERMANY

Germany's sophisticated disaster management system is characterised by a process of task-sharing between the Federation and the federal states (Länder) that is anchored in the Basic Law. The two-way carve-up of civil protection in a state of defence (Federation) and peacetime disaster control (Länder) creates a policy area with several echelons and a plethora of authorities (Federation, Länder, counties, parishes), aid organisations and support forces.

Responsibilities and measures are defined in numerous laws and ordinances. The Civil Protection and Disaster Assistance Act of the Federation represents an important basis for disaster management at operational level. The revised version of 29 July 2009 aimed to achieve greater integration between the capacities of the Federation and those of the Länder. The Federation augments the disaster control structures of the Länder in numerous areas. At the same time, the facili-

ties and forces of the Länder can also be used to avert defence-related threats. Several acts based on the principles of safeguarding and of precautionary measures offer extensive options for controlling scarce structures, goods and services (e.g. in the fields of nutrition, transport, post and telecommunications). The laws of the federal states on emergency assistance and disaster control are also especially significant. In particular, they regulate the organisation and the tasks of the disaster control authorities and specify the measures to be taken in responding to disasters. Since, according to estimates, 80% of critical infrastructures are in private ownership, these laws aim to achieve a security partnership between the state and business enterprises.

On the question of disaster management, the inclusion of Germany in the Community Mechanism to facilitate reinforced cooperation in civil protection assistance interventions, which was established in 2002, is also of relevance in the context of the European Union (EU). Germany has also concluded a number of bilateral agreements on disaster assistance.

When a power blackout occurs, local authorities, institutions and organisations are initially responsible for dealing with the consequences. Depending on the situation (interregional) and the way in which the blackout develops (prolonged with significant consequences), the next-highest levels are then successively mobilised up to the level of the Federal Ministries. Responsibility thus lies with the higher disaster control authorities, which commissions the (local) subordinate disaster control authorities with (operational) implementation of the required measures.

To reconcile this heterogeneous combination of players and their different management and communications structures, it is necessary to convene crisis units at all levels (parish, federal state, Federation) if a prolonged power blackout strikes and extends across regions. Interregional coordination is necessary to ensure coordination of the different activities by the aid organisations (e.g. German Red Cross, Maltese Cross Relief Service, fire services) and support forces (Federal Agency for Technical Relief, Federal Police and Federal Armed Forces). Presumably, the Federation would also need to become involved and assume at least a coordinating role.

In this context, various supportive systems and processes for obtaining, processing and disseminating information are available – such as the Internet-based German Emergency Planning Information System (deNIS), which serves to inform the public (deNIS I) as well as ensure direct (information) management of major disasters (deNIS II plus). In addition, the SatWaS satellite-based warning system enables the national dissemination of alerts to all situation centres, civil protection liaison offices, broadcasting corporations and other media. The main task of the German Joint Information and Situation Centre (GMLZ) is to ascertain a uniform assessment of the situation.

CONSEQUENCES OF A PROLONGED AND WIDESPREAD POWER BLACKOUT

Causes of prolonged, interregional power blackouts include technical failure and human error, criminal or terrorist acts, epidemics, pandemics or extreme weather events. Many people expect the likelihood of power blackouts to increase in future, not least because of an increased risk of terrorist attacks and climate-related extreme weather events as causes of a network collapse. Experiences of previous national and international power blackouts indicate that major damage can be expected. Although previous power blackouts have lasted for a few days at most, some have caused estimated costs amounting to several billion US dollars. A power blackout lasting several weeks is likely to cause far higher damage.

The various critical infrastructure sectors rely heavily on a continuous supply of electricity. The consequences of a power blackout extending across several Länder and lasting for at least 2 weeks would be tantamount to a disaster. This situation is described in further detail below.

INFORMATION TECHNOLOGY AND TELECOMMUNICATIONS

A widespread, prolonged power blackout would have dramatic consequences for information technology and telecommunications. Some telecommunications and data services would fail immediately, or at the latest after a few days.

Within the complex topology of information and telecommunications networks there are different levels of dependence on an external power supply: with a fixed-network telephone system the (digital) end devices and subscriber terminals fail immediately, followed by the local switching exchanges. With mobile networks, end devices that are charged and can function for a few days under moderate usage would be less affected compared with the base stations that allow users to dial into the network. Due to the increased volume of calls, these are mostly overloaded within a few minutes or fail because the emergency power supply only functions for a short period.

Mass media are especially important for communicating with the population during a crisis. Some newspaper publishing companies and printing houses have emergency power supply capacities, allowing them to play a certain role in informing the population. Public-law broadcasting corporations are better prepared for power blackouts and are able to continue transmissions. However, if they have no electricity, citizens are unable to receive broadcasts via their televisions. Consequently, radio – which can be received via the millions of battery-operated devices owned by the public – represents one of the most important channels for informing the population in the event of a crisis.

With regard to communication by authorities, the current status of information does not permit an assessment that applies equally to all players and networks. For example, the communications networks of the Federation, i.e. the Berlin-Bonn Information Network (IVBB) or the Information Network of the Federal Administration (IVBV), can generally continue operations for 2 to 3 days with the aid of emergency power generators. However, this is not sufficient to allow communications to function on a broad scale.

VULNERABILITY AND COPING CAPACITIES

It can be assumed that the mobile radio technologies powered by emergency power supplies and also the grid-bound means of communication that can be used by the Federal Armed Forces, the Federal Agency for Technical Relief (THW) or telecommunications companies in the event of an incident are primarily intended to serve these organisations' own requirements; they are not designed to ensure communication by authorities, the general public and businesses over a large area.

Even in the first few days, it emerges that if a prolonged, widespread power blackout strikes, the minimum level of telecommunications services planned and required by law to cover the event of a disaster cannot be provided by telecommunications suppliers. The reserve capacities such as »uninterruptible power supply« (UPS) and emergency power generators that are maintained for key communications systems are either exhausted after a few hours or days or prove ineffective because end devices have failed.

Within a very short time, therefore, the population is deprived of the ability to communicate actively and in dialogue form by telephone and the Internet. The number of electrically powered network routers, switching exchanges and radio antennae for fixed-network and mobile telephony and also the Internet makes it almost impossible to ensure their wide-scale reconnection because thousands of battery storage units need to be charged and fuel tanks replenished. At most, it may be possible to partially reactivate individual infrastructure elements towards the edges of the area affected by the power blackout. Moreover, the failure of communications infrastructures also affects the authorities and task forces, who use the remaining/partially restored communications capabilities on a priority basis.

It would appear that from an economic and technical point of view, it is not currently possible to ensure sustained safeguarding of communications networks to enable a stable, extensive portfolio of services to be maintained for customers.

As far as can be determined, concepts offering at least a defined minimum level of service in the event of a prolonged power blackout have not yet been developed.

NEED FOR INFORMATION AND ACTION

The above assessment of the vulnerability and coping capacities of the »information technology and telecommunications« sector in the event of a prolonged, widespread power blackout harbours numerous uncertainties. There is therefore a clear need for further information and research.

- In principle, such research should include estimating the minimum level of communications for the scenario presented in this report; this would then make it possible to determine the underlying technical conditions required for various levels of supply. Corresponding sub-areas to investigate could include an estimate of customary communications and data flows and also an assessment of existing redundancies and of network segments and nodes of critical importance for operations.
- In addition, existing concepts for emergency power supplies in the field of information technology and communications could be reviewed and new, improved approaches developed. In this context, it would be necessary to establish an overview of emergency power supplies for the various communications networks and services. The same applies for the capacities and possible uses of telecommunications emergency power systems that can be used on a mobile basis and that have to be supplied with emergency power. This would make it possible to specify the technical requirements for a crisis communications network that is, for example, reduced to major cities and central nodal points.
- Research should also examine possible adjustments to the contingency measures prescribed by law. Corresponding legal/scientific analyses should aim to identify means for increasing the resilience of the information technology and telecommunications sector in the event of a power blackout.
- Finally, it is important to mention forward-looking analyses of the framework conditions for the sector. These should consider technological innovations (electro-mobility, »intelligent« networks) and also political (liberalisation, privatisation and deregulation), economic (diversity of competing suppliers, rapid product change) or socio-cultural changes (such as changes in forms of communication and media usage among the population). There is a need to investigate whether research and development processes could be encouraged in order to develop IT and telecommunications applications that are less heavily dependent on the power supply network.

TRANSPORT AND TRAFFIC

In the »transport and traffic« sector, electrically driven elements of the transport modes road, rail, air and water either fail immediately or after a few hours. This applies both to means of transport and also to infrastructures, as well as to the management and organisation of the respective transport modes. Important factors include the abrupt shut-down of rail transport and logjams of individual motor traffic and local public transport in densely populated areas. While port operations largely come to a standstill, airports prove relatively robust and resilient.

Immediately after a power blackout, road traffic becomes chaotic, especially in major cities. Junctions and also numerous tunnels and barrier systems are blocked and long traffic jams start to form. There are numerous accidents, some of which result in injuries and fatalities. Emergency medical services and task forces encounter major difficulties in carrying out their duties (e.g. caring for and transporting injured persons or fighting fires). Since most petrol stations are out of action, numerous vehicles become stranded and individual motor traffic falls sharply after the first 24 hours. Due to the shortage of fuel, local public transport can at most be maintained at a rudimentary level. Traffic on motorways is less affected throughout the entire duration of the power blackout.

The power blackout brings electrically-powered rail transport to an abrupt standstill. Large numbers of people are trapped in underground trains and in railway carriages. The functions of control centres, signal boxes and safety technologies are drastically restricted. The curtailing of rail transport dramatically curbs the population's mobility.

With air transport, ground operations at major airports are ensured throughout the power blackout thanks to emergency power systems and fuel supplies. Aircraft can therefore still take off and land to a limited degree.

The far-reaching consequences of the power blackout for shipping are particularly evident in ports. Here, the power blackout interrupts the loading and unloading of ships because, for example, the conveyor belts or electrically operated cranes no longer work. All processes falter, all port operations come to a standstill and goods pile up. Whereas the loss of inland ports has a mainly regional effect, the loss of sea ports as centres for the transhipment of national and international goods is felt throughout Germany and even across Europe.

VULNERABILITY AND COPING CAPACITIES

The consequences of a power blackout set in abruptly and on a massive scale. Numerous accidents, stranded trains and underground trains, diverted flights, lorry jams and stockpiles of goods in ports result in major restrictions in mobility and goods transport. In major cities and conurbations in particular, traffic jams and accidents produce chaotic situations on the roads. Fire-fighting, emergency medical services and patient transport operations, interventions to ensure emergency power supplies and a number of additional measures to manage the general damage situation are significantly hampered. Since all petrol stations are out of action, fuel for emergency vehicles becomes scarce. Moreover, there is a threat of major bottlenecks in supplying the population with, for example, food or medical requisites.

The authorities and aid organisations are thus faced with complex challenges. At local level it is, for example, necessary to ensure an adequate supply of fuel for task forces and for the emergency generators of particularly sensitive critical infrastructure components (such as emergency control centres, water works, and hospitals). In addition, it is necessary to clear, block off and impose traffic bans for important stretches of road and rail transport to ensure they are made and kept clear for the emergency task forces. Finally, it is necessary to establish (interregional) transport axes and to make transport capacities available in order to ensure the supply of essential goods, especially by rail. During the power blackout, the relevant authorities must consult with logistics companies and the rail operators to decide which routes should be kept open and which measures should be implemented to ensure emergency operation.

In the sub-sector of »air transport«, current arrivals and departures can in some cases still be processed thanks to an extensive emergency power supply. However, German air traffic control will soon reduce or prohibit aircraft movements, forcing airlines to divert flights to areas not affected by the power blackout. At airports, ground operations must still be maintained, site security must be ensured and passengers who are still at the airport must be looked after. It is also necessary to examine to what extent supply flights are possible (where applicable as visual flights) for the population concerned.

In view of the serious disruptions at inland ports and sea ports in the sub-sector »water«, the relevant port authorities attempt to reduce port operations, to clear stockpiles of goods, to contact ships and ports in Germany and Europe that are not affected and to communicate with the relevant authorities in a bid to divert the transport of goods and process it via road and rail. The fire service and the Federal Agency for Technical Relief (THW) are used where necessary, e.g. to establish a temporary power supply using mobile generators or if dangerous situations arise in connection with hazardous goods. This presents major difficulties given the breakdowns in information and communications technology.

WATER SUPPLY AND WASTEWATER DISPOSAL

Water is a non-substitutable foodstuff and guarantees minimum standards of hygiene; as such, it is an indispensable resource for meeting basic human needs. However, water is also of major importance for trade, the retail sector, industry and public institutions. After just a very short time without electricity, water infrastructure systems can no longer be operated. The consequences of a failure in the water supply would be catastrophic, especially as regards supplying the population with drinking water.

In the field of water supply, electrical energy is required for the transport, treatment and distribution of water. Electrically operated pumps are especially critical for guaranteeing the respective functions. If these pumps fail, it becomes impossible to pump ground water and obtaining water from surface waters is, at the very least, heavily impaired. In addition, treatment plants and the distribution system can only be fed by natural gradients, meaning considerably less water can be made available and high-lying areas can't be supplied with any water at all.

The reduced water supply also affects wastewater disposal: For example, the volume of foul water falls, and the composition of foul water changes. There is therefore a risk that the highly concentrated wastewater will form deposits in the sewerage system and lead to blockages and smells. Since wastewater lift pumps often have no emergency electricity back-up, wastewater may escape from the pipes. Sewage plants are generally equipped with emergency power supply capacities which allow full-load operation. If the emergency power supply fails, wastewater volumes have to be stopped before they enter the sewage plant and must be fed into the surface water. This inflicts direct damage on the environment.

An interruption to the water supply has a major impact on domestic life: It becomes impossible to maintain normal personal hygiene and most households have no hot water. The ability to prepare food and drinks is limited and toilets can't be flushed. The longer the blackout lasts, the more pronounced the problems are likely to become. People soon run out of clean clothes and the hygiene situation becomes precarious. Toilets become blocked. There is a growing risk of disease spreading. Another indirect consequence of a power blackout is a growing risk of fires – in industry as a result of the failure of cooling systems and process control systems or in households as people attempt to cook or heat and light their homes without electricity. The reduction in or loss of water supply impairs fire-fighting capabilities, meaning that especially in towns with their high population densities, there is a risk of fires spreading through blocks of flats and even across entire districts.

VULNERABILITY AND COPING CAPACITIES

In Germany, the effects of a power blackout on the water infrastructure systems vary considerably from region to region. It can, however, be said that most of the drinking water and wastewater storage facilities in the networks and plants and also emergency power supply capacities are at most designed to bridge supply interruptions lasting just a few hours.

Managing the direct and indirect consequences of a power blackout requires measures involving considerable effort/expense in terms of manpower, organisation, time and material. This includes supplying the public via emergency wells (5,200 in Germany) and the use of mobile toilet trailers. Other measures include maintaining the supply and disposal networks at low levels of operating performance by means of bridging measures and functional replacement of individual components and systems that depend on the power supply. In particular, this requires the use of mobile emergency power generators. These must be operated at alternating sites, e.g. at pump facilities in the sewage network or on electric pumps within the water supply network. As long as an emergency power supply is available, the water supply can be operated with a limited level of performance, restricted availability in the distribution network and/or reduced drinking water quality. Water potability can then be ensured by consumers, e.g. through the use of sterilisation products. Whether these measures are capable of coping with disasters over a prolonged period is doubtful, especially in view of the scarce emergency power generator capacities.

NEED FOR INFORMATION AND ACTION

Since water infrastructure systems are of paramount importance for supplying the population, there is a need to develop advanced safety concepts. The technical rules of the German Technical and Scientific Association for Gas and Water (DVGW) already contain numerous elements of the Water Safety Plan of the World Health Organisation (WHO). However, since there has been little emphasis on risk assessment in the field of water extraction, treatment, storage and distribution, analyses are required in order to make it possible to prioritise the measures that need to be developed. Existing vulnerability analyses reveal that the consequences of a prolonged power blackout for the water infrastructure have not yet been investigated on the basis of models. Models that consider the water infrastructure as part of a mesh of interacting infrastructures could prove particularly suitable. Findings could prove helpful when developing a preventive disaster management system.

Vulnerability and resilience factors should be increasingly integrated into planning for future systems. For example, more intensive R&D work is already being conducted in the field of wastewater treatment plants with a view to increasing energy efficiency and the production of autonomous energy through the conversion of biogas into electricity at cogeneration power stations. Even with the current level of knowledge, it is conceivable that expanding this technology would make it possible to achieve a self-sufficient energy supply. Isolated network capability of local power generators could help improve the sector's resilience following a power blackout. These systems should aim to enable the simple and safe transfer of sewage treatment plants to an autonomous operating status. As central elements of the infrastructure, water works should also work towards achieving energy self-sufficiency and isolated network capability.

In the short-term, there is a need for improvements to non-system-based safety concepts. In the case of sewage treatment plants, for example, there are still considerable shortcomings in terms of fitting plants with systems for continuous power supply, in terms of emergency power generators and in terms of furnishing the plants with operating resources (e.g. diesel) for a prolonged period.

The field of fire protection offers opportunities for reducing vulnerability – for example by developing and using new technologies that reduce water requirements through more effective use of fire-fighting water.

FOOD SUPPLY

The food sector covers the complex supply chain from raw materials production through to the purchase of finished products by the end consumer. A power blackout causes major disruption to the supply of foodstuffs; demand-based provision of foodstuffs and their distribution among the population become priority tasks for the authorities. Successfully managing the supply of foodstuffs is vital not only for ensuring the survival of large numbers of people but also for maintaining public order.

Within the first few days, a lack of air conditioning and ventilation results in damage to the production of fruit and vegetables under glass, and to goods in storage. In animal husbandry, stall facility functions for maintaining the life and health of animals are initially ensured through (prescribed) emergency power generators. However, the loss of other stall and milking technologies has a detrimental effect on the animals' well-being and in the case of dairy cattle can lead to udder infections and ultimately to death. As soon as the supply of fuel for emergency power generators is exhausted (generally after 24 hours), the animals start to suffer because it is impossible to supply them manually with food, water and fresh air. Most problems are encountered in looking after pigs and poultry kept in groups of several thousand animals. Under such conditions the animals often don't even survive the first hours.

The food processing sector often comes to an immediate standstill, thus interrupting supplies to retail warehouses. Although these warehouses keep extensive stocks of foodstuffs, these are mostly in the form of frozen/chilled products. Only a few warehouses are able to maintain the necessary emergency power supplies for longer than 2 days. This has a massive detrimental impact on the rate of goods turnover and thus on supplies to branch outlets. Shelves empty within a matter of a few days.

VULNERABILITY AND COPING CAPACITIES

The increased demand makes the food trade industry the weakest element in the food supply chain. Serious food supply bottlenecks can be expected after just a few days. As part of their disaster management efforts, the authorities can take the following measures:

- The rationed release of stocks of the »civil emergency reserve« and of the »federal reserve of grain« is initiated on the basis of the Emergency Food Supply Act. Where possible, these stocks undergo further processing and are distributed via collective care centres.
- Transport capacities are made available on the basis of the Traffic Services Act (VerkLG). Measures are also put in place to step up interregional supplying of the affected region by the trade sector.
- Food handout centres are set up in selected retail food branches. These are equipped with emergency power generators and given consideration during the allocation of fuel. The relevant companies coordinate the required logistics in consultation with the authorities.
- Since most people are unable to prepare hot meals, large canteens are for example set up by the THW, the German Red Cross and the Federal Armed Forces, or hot meals are handed out.

Despite best efforts, however, it is highly unlikely that it will be possible to ensure satisfactory extensive distribution of food supplies to meet requirements. Communicating information on stocks and demand between headquarters, warehouses and branches is made considerably more difficult because of the failure of telecommunications connections. Disaster management by the authorities suffers considerably from the lack of a uniform picture of the situation; this also significantly hampers interregional planning and coordination of measures.

NEED FOR INFORMATION AND ACTION

Key starting points for improving the sector's resilience in terms of food supply include the regional central warehouses of retail trade operators and in some cases selected branches. These could be equipped with a reliable emergency power supply. If power supply points are available this would enable the use of mobile generators, although their use would have to be ensured over a long period. Another possible course of action would be for the central warehouses to have an autonomous power supply based on renewable energies, thus permitting a high level of self-sufficiency.

The possibility of public-private security partnerships to strengthen the sector's resilience could also be examined. The starting point could, for example, involve a concept aimed at an agreement with the retail sector to provide one branch outlet suitable for coping with disasters for every 10,000 inhabitants and also a food warehouse in every federal state that was equipped with extensive stocks, means of communication and emergency power generators. Isolated-network-compatible decentralised power generators that use renewable energy sources could also be considered for suitable locations. These would be included in a central database, which could be used by authorities and companies to coordinate deliveries in the event of a disaster.

HEALTH CARE SYSTEM

Almost all institutes involved in supplying medical and pharmaceutical products/services to the population rely directly on the supply of electricity. Consequently, the health sector, which is organised on a decentralised basis and is heavily based on the division of labour, is only able to withstand the consequences of a power blackout for a short time. Within one week, the situation deteriorates to such an extent that even intensive deployment of regional relief capacities is unlikely to prevent an extensive collapse in the supply of medical and pharmaceutical products and services.

After just 24 hours, there is a marked decline in the health sector's ability to function. Hospitals can maintain only limited operations with the aid of emergency power generators; dialysis centres and old people's homes and nursing homes must at least be partially cleared and functional areas have to be closed. Most doctors' surgeries and pharmacies can't continue operating without electricity and are shut.

Drugs become increasingly scarce during the first week as the production and sale of pharmaceutical products in the area affected by the power blackout is no longer possible and stocks at hospitals and at any pharmacies that remain open become increasingly fragmentary. Perishable drugs in particular can only be obtained in hospitals, if at all. Bottlenecks in the supply of insulin, blood products and dialysis fluids have dramatic consequences.

VULNERABILITY AND COPING CAPACITIES

With its decentralised structure, after just a few days the sector finds itself unable to cope with autonomous management of the blackout's consequences. Alongside increasing exhaustion of internal capacities, the efficiency of the health system is also reduced by the failure of other critical infrastructures. Shortages in the supply of, for example, water, foodstuffs, communication services and transport services exacerbate the problems in terms of the scope and quality of medical care.

The emergency medical services can only be used to a limited degree for transport and evacuation missions. Many emergency calls by the public are unable to get through to them because of the damage to the communications infrastructure. Coordinating the deployment of the emergency forces also becomes considerably more difficult. The dwindling availability of fuel also presents problems. This has a huge detrimental impact on pre-clinical medical care.

The care focussed in hospitals threatens to collapse. Initially, some hospitals can maintain a reduced level of operations and thus become central hubs for medical care. In most cases, they still have certain stocks of medications and sufficient staff and fuel. Medical staff involved in outpatient care support the work of the hospitals. However, this relatively good situation means that when other facilities (such as old people's homes, nursing homes and dialysis centres) have to be evacuated, their patients are sent to hospitals, threatening the collapse of the capacities that still exist. Although hospitals' emergency plans make provision for discharging as many patients as possible, the disastrous situation outside the hospitals means that at most, it is only possible to discharge patients who can look after themselves independently. Even initial assistance by the Federal Armed Forces within the framework of »civil–military cooperation« can at best provide only selective relief.

A disaster would be likely by the end of the first week at the latest; this would entail damage to the health of or the death of very large numbers of people and would create a problem situation that could not be overcome using locally/regionally available resources and personnel capacities. Without the additional external input of medical goods, infrastructures and specialist personnel it becomes impossible to provide medico-pharmaceutical care.

NEED FOR INFORMATION AND ACTION

Hospitals play a key role as anchor points for medical care of the population. Although they do exhibit a certain level of resilience, this is not enough to compensate for the loss of all other facilities – especially decentralised outpatient care. Continuous replenishments of fuel must therefore be ensured for the existing emergency power generators that are mostly available. To a limited extent, this would require the storage of fuel on-site or agreements with suppliers (who would probably find it difficult to effect deliveries because of the general consequences associated with the power blackout). In principle, feed points for emergency power supplies need to be provided for when planning hospital buildings. Ultimately, hospitals should be defined as having priority entitlement for the allocation of fuel by the disaster control authorities. A more far-reaching approach is to ensure the highest possible level of energy self-sufficiency and isolated network capability; work on this has already started in many hospitals within the context of environmental protection efforts and measures to reduce energy consumption. Possibilities for treating water/transporting water from emergency wells to hospitals/emergency hospitals should be examined in greater depth to ensure the supply of drinking water to hospitals.

Improved stocking of medical supplies could help increase resilience significantly. The inclusion of additional derogations in the Pharmaceuticals Act could also be considered to accommodate emergencies and disasters. The aim must be to ensure practical regulations for a prolonged disaster situation and to ensure supplies for the population. Finally, it would appear necessary to include manufacturers and wholesalers and also pharmacies in disaster management. This would require all the aforementioned players to take precautions to ensure the manufacture and distribution of supplies in the event of a prolonged power blackout. In this context, it is necessary to examine in which (legal) form this could be implemented.

FINANCIAL SERVICES

Individual sub-sectors of the financial services sector appear relatively resilient, even when faced with a widespread and prolonged power blackout. According to experts, the transmission of data and payments between banks, the clearing organisations and the stock exchanges, and also data management and also other critical business processes can be guaranteed for a long period through the use of emergency power supplies or can be outsourced to a region that is unaffected by the blackout. Even within the stock exchange system, the measures planned for disasters are sufficient, in technical, personnel and organisational terms, to ensure essential operations for the duration of the power blackout.

VULNERABILITY AND COPING CAPACITIES

The communication paths between the banks, clearing organisations and trading centres on the one hand and on the other hand the individuals and companies who demand financial services prove less robust. The failure of the telephone networks and of the Internet in the affected area means that after just a short time, it is no longer possible to process financial services. Many banks that remain open after the onset of the power blackout close after a few days. As cash dispensers have also stopped working, the supply of cash to the population threatens to collapse. It can be assumed that this and the failure of electronic payment facilities in businesses and banks will eventually lead to anger and to aggressive altercations as members of the public find themselves unable to effect payments.

The lack of electronic payment facilities and the dwindling ability to supply cash to the population prove to be the Achilles heel within the sector. This increases uncertainty amongst the population. People become afraid they will no longer be able to buy food and obtain other daily requisites. Informing customers and appropriate communication of risks in consultation with the disaster control authorities thus assume increasing importance.

NEED FOR INFORMATION AND ACTION

The German Federal Bank must work with other organisations and emergency forces involved in civil protection to ensure at least a rudimentary supply of cash to the public. The banks need to be included in this process. A comprehensive organisational and logistics concept needs to be developed to ensure the delivery and issuing of cash. An enhanced security concept also needs to be developed as it is uncertain whether private security companies could sufficiently guarantee the delivery of high volumes of cash.

CASE STUDY ON »PRISONS«

Emergency power generators initially enable correctional facilities to maintain their principal operational functions. These mainly involve securing the prisoners and the provision of basic services (lighting, ventilation, heating). The first phase of the power blackout proves the most chaotic. A daytime power blackout is particularly problematic as large numbers of prisoners are not in their cells. All security elements, building services facilities, IT equipment and means of communication without an emergency power supply stop working. This makes it necessary to shut the prisoners in their cells on a long-term basis. Alongside the resulting psychological stress, prisoners also experience health problems due to deteriorating hygiene conditions, inadequate food supplies and a lack of heating.

The staff at correctional facilities also experience increasing stress levels and over-tiredness. Added to this, traffic problems mean some staff arrive late or are unable to get to work at all. These factors combine to increase the overall risk of insubordination and unrest. Due to the effects of the blackout on other sectors, police forces and other support forces cannot be relied on to provide relief. Ensuring the supply of power through emergency power generators now assumes top priority. This is the only way to ensure (reduced) operations and adequate monitoring of the prisoners. Even if this succeeds, the situation becomes increasingly difficult to control – not least due to hygiene, medical and other supply problems. The situation is exacerbated if the number of detainees rises due to an increase in crime and arrests in the affected area.

VULNERABILITY AND COPING CAPACITIES

On-site fuel reserves at correctional facilities are probably only sufficient for a few days. The availability of mobile emergency power generators and the delivery of additional quantities of fuel are therefore imperative to ensure emergency power supplies. If emergency power supplies are jeopardised, transferring prisoners to other correctional facilities outside the affected area that have not reached their maximum occupancy rates is almost unavoidable.

Even if emergency power supplies are functioning, a correctional facility's ability to cope would be called into question after a few days due to security and health problems. Consequently, and due to the risk of escapes, a decision must be taken to evacuate the correctional facility and steps taken to initiate the process. This could trigger huge coordination problems because of the loss of fixed-network and mobile telephone systems. It is also doubtful whether it would be possible to call on sufficient and suitable transport capacities or indeed the necessary security personnel.

NEED FOR INFORMATION AND ACTION

It is not possible to identify explicit statutory regulations on emergency power supplies for correctional facilities. It was not possible to clarify with certainty whether relevant standards exist at the level of administrative regulations, based on the disaster control and assistance acts of the federal states. It is also uncertain whether a prolonged power blackout forms part of correctional facilities' emergency plans or of alarm and emergency plans of the subordinate disaster control authorities and whether corresponding exercises are organised with the involvement of external support forces. There is a need for further information and legal clarification concerning situations where possible exceptional measures become necessary (e.g. non-acceptance of day-release prisoners or targeted release (»prison leave«) for certain groups of prisoners.

The sector-based consequence analysis of a power blackout revealed the limited capacities for managing the consequences. Moreover, the significant interdependence of the sectors further reduces resilience and limits opportunities for the assistance system. This assessment is further substantiated below, and some cross-sector conclusions are provided.

BEHAVIOUR

If the power supply fails, everyday activities are called into question and customary communication paths become largely unusable. The associated perils and uncertainties unsettle citizens and shatter their confidence in their ability to control their living conditions. This is compounded by the fact that those affected are unprepared when the power blackout strikes and by the uncertainty concerning the duration of the blackout. If supplies slow down, if there is a lack of information and if public order starts to collapse, individuals feel helpless and experience stress.

Fear and uncertainty do not trigger uniform reactions in terms of human behaviour. On the contrary, a broad range of different, sometimes conflicting reactions is likely. Some individuals and groups abandon the established standards of community living. They become less considerate, more aggressive and more prone to violence. Willingness to help can wane. However, other responses may include cooperation, empathy and a willingness to help, with the people concerned feeling this helps them cope with the disaster.

For the members of the aid agencies, the consequences of the power blackout include extreme stress and physical and psychological strain. A lack of resources and insufficient coordination at local level, combined with different organisational cultures can trigger inappropriate behaviour when people are faced with danger; it can also hamper efficient communication and cooperation between the emergency forces or incite conflicts among helpers.

The behaviour of groups and individuals in a disaster situation has still not been researched in sufficient depth. There is, for example, a lack of analyses on how people behave in terms of protecting themselves, escaping and providing support and on the accumulation of stresses in prolonged situations of threat. At the same time there are, however, a number of largely dubious assumptions – especially concerning expected, largely antisocial, apathetic or panic-stricken behaviour by the public. Further clarification is therefore required on this aspect – especially regarding the possible ways in which the public can provide assistance in disaster situations. Using the example of a power blackout, differentiated research efforts could contribute to an analysis of human behaviour when people are faced with threats and also of misdemeanours and their respective causes; such issues have not been considered in any great depth in disaster research to date. Such studies should also consider the behaviour of helpers. There is also a need for information and research concerning communication and cooperation between organisations. More detailed socio-scientific and interdisciplinary analyses should be conducted to identify further factors that promote/inhibit communication.

LEGAL ASPECTS OF DISASTER CONTROL

The consequences and chains of consequences triggered by the power blackout create a situation in which the lives, the physical integrity and the security of the population are threatened to a high level and in which major material damage occurs. A threat and damage situation develops requiring the mobilisation of interregional resources to enable the state to meet its duty of protection. Corresponding requirements have been created by the legislator and regulator at legal and administrative level.

For example, various contingency acts can be used to activate disaster control capacities in order to support regional capacities. This opens up the following options:

- Elements of the Federal Armed Forces are mobilised within the context of »civil-military cooperation«. As well as providing personnel support (e.g. for the police, disaster control authorities or health establishments), this also makes material resources available. For example, hospitals and collection centres can be equipped with camp beds and tents, large canteens can be set up or Federal Armed Forces vehicles can be used for transport and evacuation measures.
- Certain (mainly public) operators can be granted preferential access to telecommunications and postal services on the basis of the Law Concerning the Transformation of the Deutsche Bundespost Enterprises into the Legal Structure of Stock Corporation (PTSG) and a corresponding statutory instrument by the Federal Ministry of Economics and Technology (BMWi).
- To safeguard food supplies, the Emergency Food Supply Act (EVG) permits recourse to the »civil emergency reserve« and the »federal reserve of grain«.
- Following declaration of a special emergency situation by the Federal Government, private companies can provide transport capacities under the Traffic Services Act (VerkLG) to support the area affected by the crisis. The Federal Office for Goods Transport makes these transport capacities available to the agencies requesting the assistance.

To safeguard fuel supplies, the Federal Ministry of Economics and Technology (BMWi) can issue a statutory ordinance to release stocks on the basis of the Petroleum Stockholding Act. Fuel can be made available and distributed via the rail network using diesel-driven vehicles or by tankers.

In combination with other state legislation and statutory instruments and official implementing provisions, the prerequisites for mobilising disaster management capacities even outside of the affected area have been established on a comprehensive and differentiated basis in order to ensure specific and cross-sector requirements are met.

At the same time, this plethora of legal materials appears excessively complex with little evidence of coordination. For example, the legal bases for disaster management in the »health« sector are set down in at least eleven federal and state laws and ten statutory instruments/administrative regulations. This range of instruments must be used by the relevant players at the various levels in an objectively appropriate way, at the correct time and in a way that ensures all instruments are coordinated with each other. This is only possible if the crisis units have competent specialist personnel, if there is a common understanding of the regulations and if foresighted precautions are taken to ensure the laws and statutory instruments are applied to optimum effect. It would appear these requirements are not yet met.

PRIVATE SECURITY PARTNERS

The task of ensuring well-coordinated emergency and crisis management is made even more complex because of the need to include relevant players from outside the authorities. Alongside the energy utility companies, these include numerous additional companies such as information and communications companies, the food industry or the security industry. The plurality and heterogeneity of these establishments complicate this task considerably. By way of example, the »water« sector has 5,200 organisations involved in the supply of water and 5,900 involved in water disposal, while the »information technology and telecommunications« sector has 3,000 service providers. Some of these operate on a local basis, others at interregional level and all have very different capabilities and capacities in terms of crisis management. Due to the plurality and heterogeneity of the possible security partners available to the authorities, it can be assumed that there is a need for further optimisation in recruiting private security partners at county and federal state level and in integrating them within crisis prevention and management.

NETWORKED DISASTER MANAGEMENT – COMMUNICATION AND COORDINATION

Modern information and communications technologies are virtually indispensable for generating a uniform picture of the situation and for coordinating the numerous regional and interregional crisis units and operations control centres. Following a power blackout, however, it becomes virtually impossible to access public communications infrastructures. Moreover, the available management capacities and the authorities' own communications networks are not designed to withstand a prolonged power blackout.

- Public safety authorities and organisations (BOS) communicate via the closed BOS radio network. A nationwide digital radio network is to be established by 2012. However, in terms of dependence on the power supply, the modernisation of the BOS radio network will create greater vulnerability in the event of a power blackout. Whereas the analogue relay stations had an emergency power supply that could last for 4 to 8 hours, the base stations of the new system are only designed to allow battery-based bridging of 2 hours.
- The Federal Armed Forces use the digital TETRAPOL radio network, which enables mobile voice and data communication. This is not directly compatible with the digital BOS radio network. Since the Federal Armed Forces are unlikely to be deployed until after a few days, the BOS radio network will no longer be functioning by this time.
- The local crisis units would also have the option of resorting to mobile radio stations that are not dependent on the power supply network. The telecommunications companies and also the THW and the Federal Armed Forces have alternative network equipment that enables them to establish voice and data services and supply them via emergency generators. However, the emergency generator capacities of the THW, for example, are limited. They are primarily intended for communication by the crisis units and operations control centres. The capacities of the telecommunications companies are not known.
- Other possible options to be used in the event of a power blackout include the establishment of temporary field cable networks, assistance by amateur radio operators pursuant to Section 2 [2] of the Law Concerning Amateur Radio Service and the use of satellite communication. Communication by means of field cables relies on mobile power generators, which have to be supplied with fuel after a short time. By contrast, amateur radio equipment has extremely low energy requirements. Satellite telephony and satellite-based Internet connection offer adequate transmission routes, provided the required terrestrial elements (e.g. the ground stations) have a power supply.

The authorities are thus able to restore individual infrastructures on a selective basis. One option consists in supplying mobile communications base stations and the corresponding mobile services switching centre (MSC) with emergency power on at least an hourly basis. Provided a connecting chain can be established via additional MSCs, it is possible to establish connections between users within range and also in the area not affected by the power blackout. However, it is doubtful whether it would be possible to ensure a prolonged power supply or to network with other MSCs within and outside the area affected by the power blackout.

It can therefore be assumed that despite determined efforts to restore communications infrastructures, it is not possible to establish a uniform picture of the situation. Feasible technical options tend to be of a short range and duration; supply proves problematic and forces and measures can only be coordinated to an unsatisfactory degree. Disaster management by the authorities thus continues to reveal major shortcomings.

CRISIS COMMUNICATION WITH THE PUBLIC

Due to the failures in the »information technology and telecommunications« sector, dialogue-based crisis communication with the public becomes largely impossible. Since the rudimentary remaining or restored communications capabilities can only be used by the authorities for direct rectification of damage and disaster control, communication with the public is mainly reliant on local battery-based warning systems, radio announcements and sound trucks. Since radio broadcasters are also suited to broadcasting warning messages and information via the Federal Government's satellite-based warning system (SatWaS), the authorities endeavour to supply selected broadcasting stations with emergency power to ensure a means of communication during the crisis. Experience has shown that established reception centres such as mayor's offices, fire stations or church halls can become hubs for the dissemination of information. Tannoy announcements by emergency vehicles or patrols by the emergency forces offer further ways of meeting the public's need for information.

It is, however, clear that such fragmented (one-way) communication cannot meet requirements in terms of continuous, target-group-oriented crisis communication. If mains-based communication fails as extensively as described above, it will be extremely difficult to convey credibility and create trust. Since it is still largely unclear how such crisis communication could be established without electricity, there is a need for studies to examine concepts and practicality.

SUPPLYING FUEL AND EMERGENCY POWER

The availability of fuel is crucial to disaster management. The supply of fuel is, for example, indispensable for:

- Emergency vehicles of the aid organisations and support forces;
- Diesel-operated rail vehicles to evacuate stranded trains and for transport purposes and also for local public transport buses in order to maintain a minimum level of transport services;
- Emergency power generators to enable sensitive infrastructure components (e.g. emergency control centres, fire stations, mobile radio stations) to continue working.

In principle and despite the unfavourable underlying conditions (including in particular the loss of petrol stations), the existing management capacities in the form of fuel stocks offer the necessary prerequisites for ensuring the mobility required by the players involved in disaster management. For example, the petroleum stocks prescribed by law mean significant reserves of fuel are available that could cover requirements even during a prolonged power blackout. Since petrol and diesel are mainly stored in above-ground tank facilities, the tankers or tank wagons can be filled using the principle of gravity if electricity is not available.

Despite this potential there are question marks over the extent to which these capacities and resources can be mobilised and used in the event of a power blackout. For example, due to the damage to traffic infrastructures, it will not be possible to deploy transport vehicles quickly or in sufficient quantities in order to prevent fuel bottlenecks, especially in urban centres. Coordinating the distribution of fuel deliveries in line with requirements is an extremely complex task, even if it is possible to mobilise sufficient tankers of petroleum companies and logistics service providers under the Traffic Services Act (VerkLG). Since a large area is involved, problems are likely to be encountered in agreeing responsibilities, and logistics challenges will also arise. Problems are compounded by the lack of communications opportunities, meaning many places receive inadequate supplies or no supplies at all.

Overall, it is clear that extensive measures are in place to guarantee transport services in order to supply fuel in the event of a crisis. However, the specific conditions of a power blackout mean that prompt, well-coordinated mobilisation and distribution of fuel reserves becomes a critical factor in managing the consequences of a blackout.

One means of increasing the sector's resilience is to improve the resources available directly at local level. For example, measures could be taken to equip selected petrol stations with emergency power generators and to supply them with fuel on a continuous basis. Assuming such petrol stations were made available to the authorities and the relief organisations on a priority basis, the time pressures associated with delivering fuel reserves would be reduced and the mobility of the emergency forces and their ability to intervene would be guaranteed for a certain time. In order to ensure continuous operation of emergency generators, it would at the same time be necessary to replenish selected relevant security-critical locations with the necessary fuel in time.

ISOLATED NETWORKS AS A POSSIBLE MEANS OF ENSURING A STABLE POWER SUPPLY AFTER A BLACKOUT

The resilience of numerous infrastructure elements is limited by the low battery and fuel capacities of uninterruptible and off-grid stand-alone power supply systems. However, given the huge requirements and increasing competition for fuel, even nationwide expansion of stationary and mobile emergency power generation capacities would at most achieve selective, temporary improved resilience of critical infrastructures.

Concepts involving the development of isolated networks therefore appear to offer better prospects for achieving a sustained improvement in the resilience of (emergency) power supplies. By using local networked power generators, regionally restricted isolated networks could continue to generate power after a power blackout. Even the selective development and expansion of isolated networks (especially ones based on renewable energies) that was limited to public institutions that play a key role in disaster control could improve the resilience of the power supply and therefore the resilience of critical infrastructures. A model project to investigate technical and economic feasibility is therefore proposed.

PROVIDING INFORMATION TO AND HEIGHTENING AWARENESS AMONG THE POPULATION

A significant deficit exists in terms of the public's awareness and attitude. People do not consider the power supply as a critical infrastructure to be an important issue; they ignore the possibility of power blackouts and the consequences of an interruption to the power supply. People are generally quick to forget power blackouts when they do occur.

Disasters such as power blackouts are usually associated with extreme weather events and terrorism. Since natural events are perceived as unavoidable and terrorism is viewed with a certain fatalism, people believe that as individuals, they can't take precautions against what are assumed to be exclusive causes. Consequently, the public takes no noticeable steps to prepare for a power blackout and people are therefore unable to cope adequately with the consequences. In view of the meagre level of awareness concerning the risk of and threats associated with a power blackout, there is a need to consider how information and advice could be used to awaken and maintain the public's interest, thus making it possible to address citizens in an appropriate way in crisis situations. In this context, the first step would be to elaborate a scientifically based strategy for communicating risk to the public before a power blackout. In doing so, citizens should not be considered as passive disaster victims, but as capable players who can assume an active role.

CONCLUSION

The consequence analyses have revealed that even after a few days, it is no longer possible to guarantee area-wide supplies of vital/necessary goods and services to meet with the public's requirements within the region affected by the blackout. Public safety is jeopardised; the state can no longer meet its duty of protection, as anchored in the Basic Law, to protect the life and limb of its citizens. Although the probability of a prolonged power blackout affecting several federal states may be low, if such an incident did occur, the resulting consequences would be tantamount to a national disaster. Even if all internal and external forces and resources were mobilised, the situation would not be »controllable« and could at most only be mitigated.

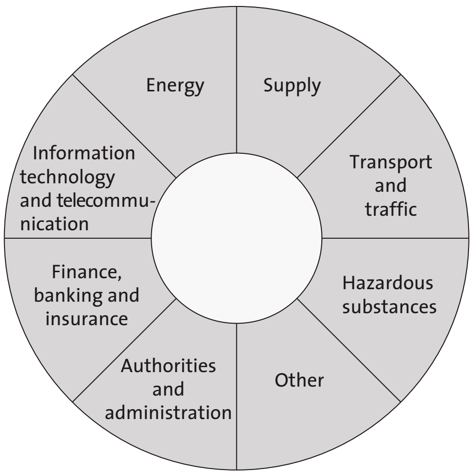
Further efforts are therefore necessary at all levels in order to increase the resilience of critical infrastructure sectors in both the short and medium-term and to further optimise the capacities of the national system for disaster control. The responsible parties within politics and society should therefore continue to accord high priority to a power blackout scenario as a prime example of »cascading damaging effects«, not least in order to also raise awareness of the issue in industry and among the public. This TAB report aims to make a contribution towards this.

INTRODUCTION I.

VULNERABILITY OF MODERN SOCIETIES 1.

Infrastructures such as secure energy transport networks, a functioning water supply, efficient transport means and routes and also information and telecommunications technology that can be accessed and used at any time are considered lifelines of modern, high-technology societies. Together with other sectors (such as authorities and the administration, health), they form the »critical infrastructures« of modern societies (Figure 1). These ensure that the population is continuously supplied with vital/necessary goods and services. They are also of fundamental importance for the quality of location and competitiveness of a national economy within the globalised international market.

FIGURE 1 OVERVIEW OF CRITICAL INFRASTRUCTURE SECTORS



Source: BMI 2009; Lenz 2009, p. 19

All sectors are, to a greater or lesser degree, closely intermeshed and dependent on each other (Lenz 2009, p. 20). Due to their high levels of internal complexity and numerous mutual interdependencies, critical infrastructures must be extensively and in some cases globally networked on an informational basis and controlled and managed at various levels. Their complexity means defects can have far-reaching consequences; even brief interruptions or the failure of even a small component can jeopardise system interactions and process flows. This also means that »increasingly fewer resources can create increasingly complex problems with increasingly more serious consequences« (Dombrowsky/Brauner 1996, p. 88). Due to their internal complexity and their (physical or logical) interconnection with other systems, functional breakdowns as an element of natural or man-made disasters can result in the social system as a whole collapsing: the information society is robbed of its (technically based) ability to generate, process, store and communicate data, and to obtain and apply knowledge. Communication stops, and mobility, the supply of energy, production and consumption decline to almost archaic levels.

The terrorist attacks in New York and Washington on 11 September 2001, in Madrid (2004) or London (2005) emphasised the vulnerability of open societies. However, their critical infrastructures are also threatened by natural disasters, particularly serious accidents, operational breakdowns or system malfunctions. Germany's dependence and vulnerability have also been highlighted several times in recent years as a result of natural disasters and technical failures (e.g. Elbe and Oder floods in 2002/2005, power blackout in the Münsterland in 2005 and in parts of Europe in 2006, the Kyrill storm in 2007 and volcano activities in Iceland in 2010). The supply bottlenecks, disruptions to public safety/security and chaotic situations surrounding aviation and road and rail transport that manifested themselves following these events also revealed the potential threats faced by modern societies. Additional risks and threats such as epidemics and pandemics, terrorist attacks or attacks using chemical, biological, radiological and nuclear agents highlight the threats faced by highly developed, technological nations. The Commission on Civil Protection of the Federal Ministry of the Interior (BMI) rightly states that »our society faces a level of vulnerability that must be taken seriously« (Schutzkommission 2006, p. 9).

The experience gained from major damage situations and the potential risks as described above have also shown that protection of critical infrastructures and efficient crisis and emergency management in the event of a disaster represent an overriding challenge. In principle, there is still agreement that identifying and analysing risks and threats and developing associated concepts for integrated protection, risk and crisis management are of vital importance for security and for (preventive) protection of the public.

Consequently, there are also increasing discussions on whether the traditional principles and structures of civil and population protection are perhaps not complex enough, given the innovative nature of many threats and also the complexity and interdependence of networked systems, processes and social action (Dombrowsky/Brauner 1996, p. 9) and if this is the case, how such principles and structures could be improved. Concern is raised, for example, because there is no uniform system of risk and crisis management among the relevant players, because there is an absence of coordinated concepts for protecting and alerting the public and because the public's self-help capabilities are not very well developed (Reichenbach et al. 2008, p. 27; Schutzkommission 2006; see also Chapter II).

A POWER BLACKOUT AS A CATALYST FOR A »NATIONAL DISASTER« 2.

The authors of the »Green Paper« of the cross-party alliance on the future of public safety and security (Zukunftsforum Öffentliche Sicherheit) have made an important contribution to heightening awareness of the risks and challenges associated with public safety and security in Germany (Reichenbach et al. 2008). Drawing on selected scenarios, they have demonstrated that in addition to causing considerable damage, terrorism, organised crime or even epidemics can also mean public safety and security can no longer be guaranteed in some cases.

The authors also emphasised that due to the virtual omnipresence of electrically operated devices and electric control systems in our living environment and our world of work and due to the fact that almost all critical infrastructures rely heavily on an uninterruptible power supply, even a widespread and prolonged power blackout can lead to huge disruptions to functions and supplies, to economic damage and to considerable threats to public safety and security and public order.[1] »Such a power blackout would be a prime example of cascading damaging effects.« (Unger 2008, p. 91) Sector-specific and cross-sector consequences would equate to or at least be akin to a catastrophe. This observation is based on two arguments. A power blackout represents a combined disaster because the electricity supply reveals interdependencies with other essential infrastructures. Almost all sectors and areas of life would be so deeply affected that it would probably no longer be possible to guarantee public safety and security or to guarantee supplies for the population (Reichenbach et al. 2008, p. 27). A prolonged power blackout would also represent a »national disaster« because as stated by the »Green Paper«, neither the public, business enterprises nor the state are prepared for such a situation (Reichenbach et al. 2008, p. 84).

Vulnerability is heightened precisely because the power supply in most advanced nations functions on a relatively reliable basis for long periods of time and be-

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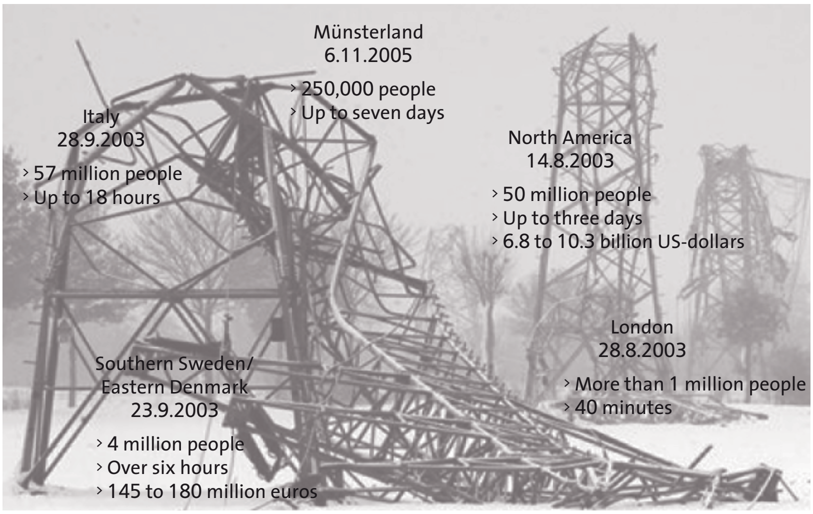
1 As early as 2004 the National Crisis Management Exercise (LÜKEX) highlighted the problematic consequences and chains of consequences and also the enormous difficulties in deploying existing capacities to manage such a crisis situation that strikes without any warning. The power blackout crisis manual [Krisenhandbuch Stromausfall] that was published at the start of 2010 confirms this view (Hiete et al. 2010). Using selected sector analyses as a basis, it addresses questions relating to crisis management in the event of a widespread interruption to the power supply, based on the example of Baden-Württemberg.

cause almost all technical systems and social actions are based on this relative reliability[2] . This »paradox in terms of vulnerability« means that where supply services are organised so that they become increasingly less susceptible to breakdown, «(the effects of) any disruption to the production, sale and consumption of supply services are all the more pronounced« (Steetskamp/van Wijk 1994, p. 20; see also BMI 2009, p. 11 ff.). However, there is limited, if any, social awareness of this potential risk. The findings of a study conducted in the Netherlands in 1994 still apply: Citizens, companies and public organisations do not consider a power blackout as a serious risk, even though such an event »can develop into a disaster-like situation« (Steetskamp/van Wijk 1994, p. 22) within the first 24 hours.

FIGURE 2 **EXAMPLES OF MAJOR POWER BLACKOUTS**



Own image

2 Germany's power network repeatedly experiences minor power blackouts at different levels of the network. For example, in 2007, the average time for which power was not available was 19.25 minutes per end consumer, while the figure in 2008 was 16.89 minutes. By contrast, until now there has never been a need to bridge a blackout lasting weeks or even months (www.bundesnetzagentur.de/DE/Sachgebiete/Elektrizitaet Gas/Sonderthemen/SAIDIWertStrom 2008/SAIDIWertStrom2008_node.html). However, it is important to note that blackouts caused by »force majeure« are not included in the statistics on non-availability. Silvast/Kaplinsky (2007) provide data and information on power blackouts in Europe.

Although some larger power blackouts in Germany and in other countries have at least given some indication of this (Figure 2), disaster research to date has – as far as can be ascertained – not yet considered the possible consequences of such an event in any real depth or to any systematic extent. As yet, there are no integrated consequence analyses for a scenario involving a »power blackout«.[3]

MANDATE, METHOD, STRUCTURE OF THE REPORT 3.

MANDATE

In view of the potential for disaster presented by a prolonged and widespread power blackout, the Office of Technology Assessment at the German Bundestag (TAB) was commissioned to undertake a systematic consequence analysis of such an event. The analysis was to examine the effects of a prolonged and widespread power blackout on society and its critical infrastructures. The analysis was also to act as a starting point for assessing the extent to which Germany is prepared for such a major damage situation.

The corresponding concept proposed by the TAB and advocated by the Committee on Education, Research and Technology Assessment initially set a broad framework. The study was to focus on examining the following:

- The vulnerability of sample sectors and infrastructure facilities and also the coping capacities of specific sub-sectors within society and the authorities,
- The limits of and possibilities for communicating risks, informing the public and mobilising their self-help capabilities and
- The possible means of action open to organisations involved in civil protection and disaster assistance

against the backdrop of a prolonged and interregional power blackout.

METHOD AND FOCAL POINTS OF THE STUDY

Due to the complex material, the differentiated structures in terms of expertise and players as regards disaster control and civil protection and also in particular the gaps in literature, documentation and data, an in-depth exploratory study was first conducted as part of an initial phase. The aim of this exploratory study was to ascertain initial findings on possible consequences and chains of consequences for selected sectors that result from a power blackout and on the ability

3 Two exceptions confirm this finding: the previously mentioned study by Steetskamp/van Wijk (1994) and the current power blackout crisis manual »Krisenhandbuch Stromausfall« (Hiete et al. 2010).

of these sectors to manage such consequences; it also aimed to develop concepts and methodical approaches for a subsequent main phase of the TAB project.

The following key points were then addressed in the main phase:

- Consequence analyses for selected critical infrastructure sectors: These analyses aimed to portray plausible consequences and chains of consequences triggered by a power blackout and thus to provide initial indications of the vulnerability/resilience of the respective sector.
- A discussion on attitudes and behaviour shown among the public: This area of the study aimed to develop some hypotheses on attitudes and behaviour patterns associated with a power blackout.
- Players and structures within the German disaster management system: This area of the study was designed to consider which players and structures within the national system for disaster control are relevant in peacetime in the event of a major damage situation caused by a power blackout.

SECTORS AND CHALLENGES

Using the findings from the initial phase as a basis, the following threat situations were analysed in more detail:

- Supplying the population with food (»agriculture/food trade« sector)
- Ensuring a minimum level of medical and pharmaceutical supplies (»health« sector)
- Maintaining the (drinking) water supply and wastewater disposal (»water and wastewater disposal« sector)
- Guaranteeing adapted mobility/transport capacities (»transport and traffic« sector)
- Enabling sufficient financial services (»financial services« sector)
- Maintaining/restoring adequate communications channels (»information technology and telecommunications« sector)
- Guaranteeing public safety and security – case study on »prisons«

This selection was based on the view that the protection, safety/security and life of the population and also the sustainability of social structures can only be guaranteed if it is possible to ensure that the public is adequately supplied with the necessary goods and services in these sectors in particular, if public safety and security can be safeguarded as far as possible and if threats to the life and limb of citizens can be averted.

ATTITUDES AND BEHAVIOUR

In principle, it can be considered that »human reactions« make a disaster, »not the wreckage, destruction or malfunctions« (Dombrowsky/Brauner 1996, p. 119). Another area of the study therefore focussed on the issue of behaviour and patterns of behaviour exhibited as a result of and during the course of a power blackout. A prolonged power blackout will create uncertainty and fear among the population, and also create threats to life and limb. According to the research on the behaviour of individuals and groups in disaster situations, it can be expected that even a power blackout would give rise both to antisocial, illegal and aggressive conduct and also to empathy, a willingness to help and rational and decisive action. There is, however, insufficient knowledge on the social and socio-psychological dimensions of such a disaster (e.g. BBK 2008a, p. 155; Schutzkommission 2006, p. 90).

Overall, it could be considered that some assumptions on the behaviour and »malleability of the population« in extreme situations need to be examined in order to allow a realistic assessment of the role of the public and of professional and voluntary helpers and link this to the issue of disaster management (Dombrowsky/Brauner 1996, p. 24). It was therefore deemed appropriate to also include the issue of behaviour in the consequence analysis. A (limited) study of the relevant literature was conducted. Since there are hardly any corresponding scientific studies on the behaviour of individuals and groups in the event of a disaster involving a »power blackout«, sources relating to other types of disaster were analysed to determine if they were transferable to a situation involving a power blackout. Instead of pursuing own research questions or collecting own data, this approach aimed to identify gaps and deficiencies in research and to put these forward for discussion.

MANAGEMENT AND CONTROL OF DISASTERS

Germany's national system for providing assistance in peacetime disaster situations provided another focus for the study. An overview of the most important relevant structures, forces and institutions at regional, national and municipal level was therefore ascertained. Emphasis was placed on the capacities of these structures, forces and institutions and their ability to act in the event of a prolonged and widespread power blackout. The relevant legal bases were also examined. No attempt was made to achieve a systematic or complete review or to conduct a jurisprudential analysis. The findings of the consequence analysis were then used to make an initial assessment of the coping capacities available within the national crisis management system.

COOPERATION WITH EXPERTS, MEETINGS WITH EXPERTS

The following expert reports were commissioned in order to provide the TAB report with a sound scientific basis:

- Vierboom & Härlen Wirtschaftspsychologen GbR (2009): Kurzgutachten für den Themenbereich »Risiko- und kommunikationspsychologische Bestim-

mungsfaktoren des Umgangs mit einem großräumigen Ausfall der Stromversorgung in der Bevölkerung«. Cologne
- Prognos AG (2009): Konzeptstudie »Gefährdung und Verletzbarkeit moderner Gesellschaften – am Beispiel eines großräumigen Ausfalls der Stromversorgung«. Basel
- Vierboom & Härlen Wirtschaftspsychologen GbR (2010): Kurzgutachten zu einer Literaturstudie über Faktoren und Maßnahmemöglichkeiten der Katastrophenbewältigung auf der Verhaltensebene. Cologne
- Ernst Basler + Partner AG (2010): Folgen eines Stromausfalls für die Sektoren/kritischen Strukturen Verkehr, Finanzdienstleistungen, IuK-Technologien sowie Gefängnisse. Zollikon

Grateful thanks are extended to the authors of these reports. They set about handling a very difficult subject that has been the focus of very few studies within a very short space of time. The experts overcame this challenge supremely and thus provided a sound basis for this report. The report's authors are responsible for any inadequacies contained in the report.

The report is also based on various information provided in writing and by telephone by institutes, organisations and companies in response to specific questions by the project team, as well as on detailed meetings with experts from the critical infrastructure sectors. These included experts from industry, authorities, science and politics, who were asked to attend meetings by the authors of the expert reports commissioned by the TAB and also by the project team. It is important to remember that some experts refused to answer questions or did not respond at all. Since not all persons who were approached wished to be or agreed to be mentioned by name in the report, it was decided not to include the names of the individual experts consulted.

The project team also received valuable support from the Federal Office of Civil Protection and Disaster Assistance (BBK) and from the Federal Office for Information Security (BSI). Grateful thanks are extended to the colleagues from the BBK and BSI for their help.

The following colleagues also assisted during the project and in drafting the final report: Dr. Harald Hiessl and Peter Zoche from the Fraunhofer Institute for Systems and Innovation Research in Karlsruhe, and also Dr. Reinhard Grünwald from the TAB team in Berlin. The authors would also like to extend their thanks to Brigitta-Ulrike Goelsdorf, Head of the TAB Secretariat, who worked so hard proofreading the manuscript and managing the report's appearance, especially in terms of images and layout.

STRUCTURE OF THE REPORT

The present report is structured as follows: Following this introduction (Chapter I), Chapter II discusses the principal structures, players, procedures and capacities of Germany's system for crisis management in relation to a major power blackout. Chapter III forms the core of the report. It contains consequence analyses for selected critical infrastructure sectors (Chapter III.2.1 to III.2.7). These are supplemented by discussions on possible attitudes and behaviour patterns that could be displayed by the public in the event of a power blackout (Chapter III.3).

In Chapter IV the most important conclusions are presented. Using the vulnerability analyses provided in Chapter III as a backdrop, it summarises the key weaknesses inherent in the sectors and also cross-sector vulnerabilities. This section also includes an assessment of the management capacities of the German system for crisis management and also outlines and discusses starting points for improving the resilience of critical infrastructures in the event of a disaster involving a power blackout. Finally, the report discusses prospects pertaining to information, research and action.

In conclusion, it should again be emphasised that the TAB project was commissioned to investigate the »consequences« of a power blackout; specifically, the mandate did not include the causes of such a blackout. This focus is firstly justified because frequent and in-depth studies are already available on the causes of power blackouts, along with recommendations for safety/security and preventive concepts.[4] Secondly, and by contrast, there are very few detailed sector-based consequence analyses on the expected effects of such blackouts. In this connection, BMI/BBK (2007, p. 188 ff.) also emphasises that in contrast to the well-investigated vulnerability of the »energy/power generation« sector, considerable uncertainty prevails concerning the precise vulnerability of other critical infrastructures following a power blackout/the degree of criticality between critical infrastructures and whether »effective consumer protection is actually possible« (BMI/BBK 2007, p. 190). There is therefore a need for studies into these issues (i.e. into the consequences of a power blackout).[5]

4 Studies of power blackouts (Münsterland, Emsland) focus on the origin of the blackout and on prevention in the sense of avoiding a blackout, but not on reducing harmful consequences.

5 In the final analysis, this statement also means that identified solution strategies do not serve to prevent a blackout in the sense of preventing its occurrence. On the contrary, the technical and political options that need to be identified involve the prevention/reduction of problematic consequences and limitation of damage (Chapter IV).

This TAB report is therefore largely treading on virgin soil. There is little literature or research available on the subject of the study. If available at all, any data on the players and resources involved in disaster protection and also any relevant statistics (e.g. on damage) or systematic evaluations of disaster operations even for such a disaster situation prove incomplete, difficult to verify and therefore also difficult to evaluate (Dombrowsky/Brauner 1996, p. 23; Schutzkommission 2006, p. 9) This report therefore only represents a pilot study on the subject.

THE SYSTEM OF CRISIS MANAGEMENT IN GERMANY II.

Germany's historic evolvement of a »security architecture« has also led to the development of an »assistance system« (Weinheimer 2008) for peacetime disaster control. This system is expected to be able to cope with multifarious threats (Chapter I) (BBK 2008a, p. 9). While disaster risk management and disaster control is the responsibility of the federal states, it is also expected to deal with risk and damage situations of national importance (such as serious radiological and biological incidents, disruptions to critical infrastructures, terrorism and also natural disasters or epidemics). The Federal Government supports the federal states in this task. Based on a »network that spans society as a whole« (BBK 2008a, p. 76), forces and institutes at national, regional and municipal level including the fire services, the aid organisations and the Federal Agency for Technical Relief combine to constitute what can, even in international terms, be considered a »unique deployment of forces«, despite the fact that »more than 80 % is accounted for by voluntary members« (Weinheimer 2008, p. 165).[6]

Some observers believe that given the extreme vulnerability of critical infrastructures and the widespread and possibly prolonged disaster situations associated with damage to or the failure of such infrastructures, the »German system of crisis management« (BMI 2008) is not yet sufficiently prepared. Among other things, questions are raised about the two-way carve-up of civil protection and disaster control and about the associated plethora of authorities, aid organisations and public safety authorities and organisations (BOS). This creates additional problems relating to responsibilities and authority, as for example with regard to the exercise of police, other civil protection and military functions or with regard to the separation/coordination of civil protection and disaster control. If the corresponding players are to work together successfully, the numerous different management and communications structures must be coordinated as effectively as possible at national and Länder level. Some people doubt whether this can succeed in widespread, extremely unstable situations if civil protection is not managed from »one single source«.

According to estimates, around 80 % of critical infrastructures are in private ownership. Consequently, a »security partnership« between the government and private companies is considered necessary in order to achieve the objectives of peacetime disaster control (BBK 2008a, p. 89 ff.; BMI 2009), and thus make it

6 According to Weinheimer (2008, p. 165), the number of personnel in the specified organisations totals 1.8 million; however, the number of people who can actually be mobilised on an operational basis is »significantly lower«.

possible to guarantee the protection of citizens[7]. Nevertheless, the Federation and the Länder retain special responsibility for this core task of ensuring national security. In recent years, the responsible government players at federation and Länder level – often acting in conjunction with representatives from industry and society – have implemented numerous activities in terms of concepts, planning, legislation and organisation in order to better fulfil this responsibility. This includes the formation of the Federal Office of Civil Protection and Disaster Assistance (BBK) in 2004 following the adoption of the »New Strategy«[8]. As a Higher Federal Authority under the remit of the Federal Ministry of the Interior (BMI), one of its key tasks is the elaboration of concepts for the analysis and protection of critical infrastructures. Its tasks also include »providing information on the importance of critical infrastructures for the government and for society, heightening awareness among authorities, companies and the general public, portraying the tasks, functions and interdependencies of/between critical infrastructures, developing and strengthening cooperation between authorities and companies, … proposing short, medium and long-term measures for the protection of critical infrastructures« (BBK n.d.).

The rewriting of the Act on Civil Protection was an important step from a legislative point of view. The Law on the Reorganisation of Civil Protection (ZSNeuOG) of 29 July 2009 redefined the division of tasks between the Federation and the Länder in the field of disaster control. It aims to create a more efficient and flexible joint system of assistance. The previous coexistence between the Länder disaster control structures and the structures prescribed by the Federation for enhancing disaster control were restructured so that augmentation of disaster control now builds on the Länder structures. Federal resources can thus also be deployed in the event of peacetime damaging events and Länder disaster control structures can also be used to avert defence-related disasters.

With regard to improving the basis of information and to improving warning capabilities, reference is made to the introduction of the German Emergency

7 Based on the »National Plan for the Protection of Information Infrastructures« (NPSI) that was adopted in 2005 (NPSI) (BMI 2005b), the BMI and the BSI elaborated the »CIP Implementation Plan« – in cooperation with around 30 major German infrastructure companies and their trade and industry associations (BMI 2007).

8 At the Conference of Ministers of the Interior at the start of June 2002, the Federation and the Länder agreed on a new framework concept for civil protection: the »New Strategy for Protecting the Population in Germany«. It is based on the principle that the Federation and the Länder have joint responsibility for threats and damage scenarios that are unusual or widespread in nature, or that are of national importance. Among other things, the new framework concept aimed to ensure improved dovetailing of assistance capabilities of the Federation (especially the THW) and of the Länder (fire brigades and aid organisations) and also to create new coordination tools for efficient cooperation. Some people question whether the »New Strategy« is still adequate against the backdrop of present conditions and of those expected in the future.

Planning Information Systems (deNIS I and deNIS II plus), SatWaS and the German Joint Information and Situation Centre (GMLZ) (Chapter II.2).

Since 2004, interdepartmental and interstate crisis management exercises have been used to practise the German system for crisis management and also the cooperation between the Federation and the Länder. These LÜKEX exercises are designed to result in a critical analysis and in corresponding measures for further development of crisis management concepts and structures. The exercises are also deliberately conceived as a joint activity between the Federation and industry. Among other things, the efforts to further develop the structures for managing unusual threat situations have resulted in plans and protection concepts (e.g. »Baseline Protection Concept«, »National Plan for the Protection of Information Infrastructures«, »National Strategy for the Protection of Critical Infrastructures« and »Protection of Critical Infrastructures – Risk and Crisis Management«).

Finally, publicly funded research is also making increasing contributions to an improved and more practical understanding of the risks and threats faced by modern industrial and knowledge-based societies. Greater attention is also being focussed on technological and social options for increasing the resilience of critical infrastructures. In this connection, it is important to mention the Federal Government's Security Research Programme, which promotes research aimed at developing practical solutions designed to increase the safety and security of citizens.

The following section outlines selected legal bases for peacetime disaster control (Chapter II.1). This is followed by an overview of the structures, players and processes that would be mobilised in the event of a prolonged power blackout (Chapter II.2).

LEGAL BASES FOR DISASTER MANAGEMENT 1.

The legal bases for managing the consequences of a widespread power blackout are provided by a broad body of legislation at both international and national level. Nationally, the rules and regulations extend from the Basic Law to implementing provisions for authorities.

INTERNATIONAL

At international level, assistance in disaster situations is regulated at the level of the EU and NATO and also through bilateral treaties.

The Community Civil Protection Mechanism, which was established in 2002, provides the EU with an instrument for combatting disasters through mutual assistance.[9] The basis for this is provided by a decision of the European Council of 23 October 2001 (2001/792/EC, EURATOM in the revised version 2007/779/EC, EURATOM). Moreover, Article 18 of the Treaty on the stepping up of cross-border cooperation, particularly in combating terrorism, cross-border crime and illegal migration of 23 June 2008 (2008/615/JI) stipulates that the competent authorities of the member states shall provide mutual assistance in connection with disasters and serious accidents. The Monitoring and Information Centre (MIC) represents the operational organ of the Community Mechanism. Each member state may request assistance via the MIC.[10] . The »Crisis Steering Group« was set up at the level of the General Secretariat of the Council of the European Union. It is responsible for crises and emergencies that have far-reaching effects and that are of major political significance. At the level of the Ministries, agreements have been concluded aimed at managing communication between the German representatives and the relevant players in Germany (BMI 2010, p. 17).

Article 196 of the »Treaty on the Functioning of the European Union« addresses the issue of civil protection. It specifies the Union's aims as supporting and complementing member states' actions in civil protection and responses to disaster situations. The necessary measures should be established in accordance with the ordinary legislative procedure, excluding any harmonisation of the laws of the member states.

According to a decision by the North Atlantic Council on 29 May 1998, NATO's disaster relief makes it possible to request assistance from member states and to coordinate the provision of such assistance on a central basis (Geier et al. 2009, p. 100).

In addition, there are numerous agreements on bilateral assistance in the event of disasters or serious accidents (e.g. with Belgium, Denmark, France, Lithuania, Luxembourg, the Netherlands, Austria, Poland, the Russian Federation, Switzerland, the Czech Republic and Hungary). There is also a framework agreement between Germany and France on cross-border cooperation in the health sector; in particular, this makes provision for a cross-border emergency medical service (Paul/Ufer 2009, p. 118). The BBK has concluded cooperation agreements with various neighbouring countries (BBK 2008a, p. 93).

9 A study by the Environment Directorate-General revealed that although the EU Mechanism currently facilitates support, it cannot guarantee it (ECORYS Research and Consulting 2009, p. 10).

10 In this context, Lüder (2009, p. 119 ff.) raises the question as to how the Community Mechanism »can be reconciled with the localisation of non-police-based emergency response across the member states and the operations information stored there«.

FEDERATION

The Basic Law (GG) regulates the division of tasks between the Federation and the federal states (Länder). Civil protection is the task and responsibility of the Federation (Article 73 No. 1 of the Basic Law). According to Articles 30 and 70 [1] of the Basic Law, responsibility for disaster control[11] in peacetime lies with the federal states. However, according to Article 35 [2] second sentence of the Basic Law, a federal state may, in response to a natural disaster or to a particularly grave accident, request the assistance of police forces of other federal states, or of forces and facilities of other administrative bodies and of the Federal Police or the armed forces. If a threat extends beyond the territory of a federal state, the Federal Government may, in accordance with Article 35 [3] of the Basic Law, instruct the Land governments to make police forces available. The Federal Government may also deploy units of the Federal Police (pre-2005 the Federal Border Police) and the armed forces to support the police forces (Paul/Ufer 2009, p. 118 and 120). Notwithstanding these two cases, Article 35 [1] allows the possibility of mutual assistance between the Federal and Länder authorities (administrative assistance).

In addition to civil protection responsibilities, the Civil Protection and Disaster Management Law of the Federal Government[12] (ZSKG) also regulates disaster control within the framework of civil protection as well as disaster assistance by the Federal Government. In this context, the use of facilities of the Federal Government pursuant to Section 12 is of particular significance. According to this provision, the Federal Government makes the facilities it keeps available for defence scenarios available to the Länder in order to assist them in their duties relating to disaster control. Conversely, the disaster control forces and facilities of the Länder are also used for defence functions (Section 11 [1]). The Federal Government augments their facilities and equipment in the field of fire protection, NBC protection and care (Section 13 [2] ZSKG).

This law made it possible for the Federal Government, following a request by a federal state or by several states affected by an incident, to coordinate the assistance measures in consultation with said federal state or states (Section 16 [2] ZSKG). Where required, the facilities of the Federal Office of Civil Protection and Disaster Assistance (BBK) are also available to the federal states, including in particular with regard to ascertaining and assessing situations and verifying and placing scarce resources (Section 16 [1] ZSKG), as they can enlist the support of the German Joint Information and Situation Centre (GMLZ) and also of

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11 A uniform nationwide legal definition exists for the term disaster control (Weinheimer 2008, p. 143).

12 Civil Protection and Disaster Management Law of the Federal Government (ZSKG) of 25 March 1997 (BGBl. I, p. 726), amended by Section 2 No. 1 of the law of 29 July 2009 (BGBl. I, p. 2350).

the deNIS database (Chapter II.2). However, management and coordination of all assistance measures is the responsibility of the relevant Länder disaster control authorities. They are responsible for operational crisis management and oversee disaster control forces and facilities as regards implementation of their duties.

Acts of a precautionary nature

By adopting several emergency preparedness and precautionary acts (see text box) and also numerous associated statutory instruments, the Federal Government has established a broad range of means of action. These acts and instruments can be used to mobilise scarce and critical resources. In addition to the precautionary stocking of key goods such as food or fuel, the precautionary acts also lay down a catalogue of measures permitting extensive control of scarce goods and services and of the corresponding infrastructures in the fields of energy, nutrition, transport, post and telecommunications.

EMERGENCY PREPAREDNESS AND PRECAUTIONARY ACTS

- *Petroleum Stockholding Act*
  Petroleum Stockholding Act in the version pronounced on 6 April 1998 (BGBl. I, p. 679), last amended by Section 165 of the ordinance of 31 October 2006 (BGBl. I, p. 2407).
- *Energy Security Act*
  Energy Security Act of 20 December 1974 (BGBl. I, p. 3681), last amended by Section 164 of the ordinance of 31 October 2006 (BGBl. I, p. 2407).
- *Emergency Food Supply Act*
  Emergency Food Supply Act of 20 August 1990 (BGBl. I, p. 1766), last amended by Section 186 of the ordinance of 31 October 2006 (BGBl. I, p. 2407).
- *Law Concerning the Transformation of the Deutsche Bundespost Enterprises into the Legal Structure of Stock Corporation*
  Law Concerning the Transformation of the Deutsche Bundespost Enterprises into the Legal Structure of Stock Corporation of 14 September 1994 (BGBl. I, p. 2325, 2378), last amended by Section 2 No. 3 of the law of 2 April 2009 (BGBl. I, p. 693).
- *Traffic Services Act*
  Traffic Services Act of 23 July 2004 (BGBl. I, p. 1865), last amended by Section 304 of the ordinance of 31 October 2006 (BGBl. I, p. 2407).

Standards and rules and regulations

Additional provisions for managing a power blackout exist in the form of standards and bodies of rules and regulations. For example, the DIN Deutsches Institut für Normung e.V. defines numerous technical requirements for safety and security (e.g. of equipment, processes, buildings).[13] The trade and industry associations also have numerous bodies of rules and regulations such as – in the field of water/wastewater – those of the German Technical and Scientific Association for Gas and Water (DVGW) and of the German Association of Water, Wastewater and Waste (DWA) (Chapter III.2.3). Corresponding standards can be used in legislation, in administration and in legal relations.

THE LÄNDER

The federal Länder are responsible for legislation relating to peacetime disaster control, the emergency medical services and public health services.[14] They are also responsible for the law relating to hospitals, taking into account the competing legislative competence of the Federal Government (Paul/Ufer 2009, p. 126).

The disaster control laws of the federal Länder are of particular significance. Eight federal Länder have special disaster control laws, while five federal Länder have implemented combined laws for fire protection and disaster control. In Bremen and Saxony, disaster control is anchored in assistance laws, which also regulate fire protection and the emergency medical services. In North Rhine-Westphalia, for example, the fire protection and assistance law regulates the management of emergencies caused by natural events, explosions or similar incidents.[15] Administrative provisions regulate key aspects of local disaster management (such as the work of task forces or announcements of threats over the radio) (Paul/Ufer 2009, p. 129). The police laws of the Länder regulate matters relating to emergency response by the police. Police service regulations specify the principles governing police work and also police measures in specific situations.

There are also disaster control plans issued by the competent authorities. These are only partly accessible to the general public. In particular, these deal with the procedure for warning the public, the emergency measures to be adopted in the event of a disaster and also the emergency forces and resources.

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13 These also include the DIN-EN standards on emergency power supplies and on emergency lighting in certain buildings or on the technical equipment of emergency vehicles.

14 The Länder are also responsible for the material resources – in conjunction with the municipalities and the aid organisations. Added to this is the Federal Government's civil protection equipment, which it also makes available for disaster control purposes.

15 The term disaster is not used; the term major damaging incident is used instead.

These laws and plans are used as a basis for organising, at the level of the subordinate disaster control authorities, disaster control and disaster assistance by other authorities and national aid organisations and also the deployment of disaster control units.

CRISIS MANAGEMENT IN GERMANY: PLAYERS, STRUCTURES AND PROCESSES 2.

The regulation of disaster preparedness and disaster control as outlined above reflects the federal system of the Federal Republic and the associated organisational sovereignty of the Länder/municipalities. One consequence of this approach is that it is not possible to ensure uniform management and coordination of and cooperation between the numerous players at multifarious levels. This situation is frequently criticised and has for example been referred to as »fragmentation of civil protection policy«

However, over the last 5 years in particular, the system of crisis management has undergone continuous further development in line with the changed threat situation (Unger 2008). At the same time, efforts have pushed ahead at European level to dovetail national crisis management systems. As part of this process, numerous measures have for example been adopted with the aim of creating a certain level of uniformity, especially at management level. In order to standardise the command and control structures at the various levels of crisis management, the Länder agreed on use of a set of basic unifying recommendations within the context of their overall management system. For example, »Fire Services Regulation 100« (FW DV 100) is to be applied to all organisations at operational and tactical level, and the »Guidelines for setting up administrative and organisational task forces« are to be applied at administrative and organisational level. The Länder also agreed on a procedure for interstate disaster assistance.

The following section outlines the crisis management system in Germany – taking into account cooperation between the various players −in the event of a prolonged, interregional disaster situation.

CRISIS MANAGEMENT AT THE LEVEL OF THE FEDERATION AND THE LÄNDER

When a power blackout occurs, local institutions, organisations and authorities (mayor's offices) are initially responsible for dealing with the consequences. Depending on the situation and the way in which the situation develops, the next-highest levels are then successively mobilised (regional commissioner, Länder ministries, federal ministries). The highest disaster control authority of a Land is generally the Ministry of the Interior. The subordinate disaster control authorities in the non-city states are mainly the counties and the county boroughs, while in the city-states they are the departments of interior affairs (Paul/Ufer 2009, p. 131 ff.). In the event of a widespread power blackout, administrative task forces at all levels step in to manage the tasks arising (Hiete et al. 2010, D4).

The competent subordinate disaster control authorities are responsible for immediately initiating all necessary measures required to avert or manage damaging events. They are also responsible for reporting situations to higher echelons in order to ensure that the necessary information and reports on the situation are also transmitted to the Interior Ministry without delay.

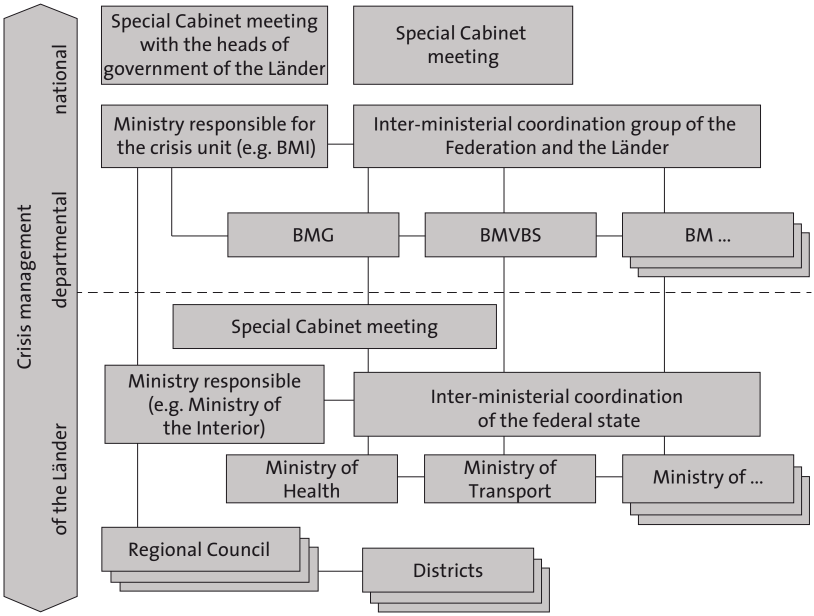
With interregional power blackouts, responsibility lies with the higher disaster control authority, which commissions the (local) subordinate disaster control authorities with (operational) implementation of the required measures. It manages disaster prevention in its capacity as »local operations control centre for disaster control«. In the event of an impending or actual disaster situation, it can issue instructions to the disaster control task forces (e.g. police, fire service, THW) and to all other parties involved in disaster assistance. The individual federal forces send expert advisors or liaison officers to the local forces. According to the »Concept for Interstate Disaster Assistance« that was agreed by the Länder in 2004, the highest department of internal affairs will contact the departments of internal affairs of the neighbouring Länder and request assistance forces. The forces that are deployed report to the management authorities of the Land that has requested the assistance; the competent subordinate authorities of the neighbouring Länder are informed of the progress of the cross-state assistance.

In addition to this, the Federal Government also becomes active, at least in a coordinating role, due to the significance of the damaging event for the country as a whole. In parallel to the Länder structures, the Ministry of the Interior would also set up a crisis unit[16] with the aim of collating the available information. This includes, among other things, the competent technical departments for crisis management and civil protection, public safety and information technology, and also the BBK, the BSI, the Federal Criminal Police Office (BKA) and the Federal Agency for Technical Relief. Other departments and departmental authorities can be called on where necessary (BBK 2008a, p. 91). The basic administrative structures of department-based crisis management are shown in Figure 3.

Due to the interregional character of the power blackout, Federal and Länder coordination groups are formed. Interstate coordination within Germany is organised via the situation centres of the interior ministries and between their departments.

16 The Federal Ministry of the Interior (BMI) is responsible for coordinating natural disasters or especially grave accidents. According to the Constitution, emergency response remains in the sovereignty of the federal Länder.

FIGURE 3 SYSTEM OF CRISIS MANAGEMENT BY THE FEDERATION AND THE LÄNDER



Source: BMI 2010, p. 18

Cooperation between the Federal Armed Forces and the federal and Länder authorities and also with the districts, counties and county boroughs is regulated on a level-appropriate basis in an instruction of the Federal Ministry of Defence (BMVg) (BMVg 2008).

The German Joint Information and Situation Centre (GMLZ) plays a special role. It operates a permanently contactable information centre for widespread threat situations of national importance and assists in the placement of resources. The situation centre is considered the »heart of the national and police information network and of resource management in disaster and crisis situations« (BBK 2008a, p. 80). For example, as part of interregional disaster assistance to manage the consequences of a power blackout, the Federation can contribute by compiling a national picture of the situation.

If disaster assistance also has to be coordinated on an international level, specific capacities are available through the North Atlantic Treaty Organisation (NATO) and the Euro-Atlantic Disaster Response Coordination Centre and through the EU with its Monitoring and Information Centre (MIC). These centres allow members to exchange information with each other and to coordinate the deployment of task forces (NATO 2001, p. 21).

The Internet-based German Emergency Planning Information System (deNIS) can also be used. Its task is to combine and edit information and to make it available both to the public (deNIS I) and also for direct (information) management of major disasters (deNIS II plus[17]). The Federal Government's satellite-based warning system SatWaS can be used to disseminate alerts across Germany. It enables the transmission of high-priority alerts to all civil protection liaison offices, broadcasting stations and other media such as major press agencies and Internet service providers, and to the situation centres of the BMI and of the Länder interior ministries. A warning message sent to broadcasting corporations may include an order to interrupt the current broadcast and pass on a certain text immediately via the transmitter.

The crisis units of the ministries are especially important. Figure 4 shows the crisis units that have been set up at the federal level and whose task is to support crisis management by the Länder by providing specific departmental expertise.

FIGURE 4 **CRISIS UNITS OF THE MINISTRIES AT THE FEDERAL LEVEL**

Federal Ministry of Food, Agriculture and Consumer Protection (BMELV)	> Crisis Task Force on Food Safety > National Crisis Task Force for Animal Disease Control
Federal Ministry of Defence (BMVg)	> Operational Command and Control
Federal Ministry of Health (BMG)	> In-house crisis task force
Federal Ministry of Transport, Building and Urban Development (BMVBS)	> In-house crisis task force
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)	> Task Force for Nuclear Safety and Radiological Protection

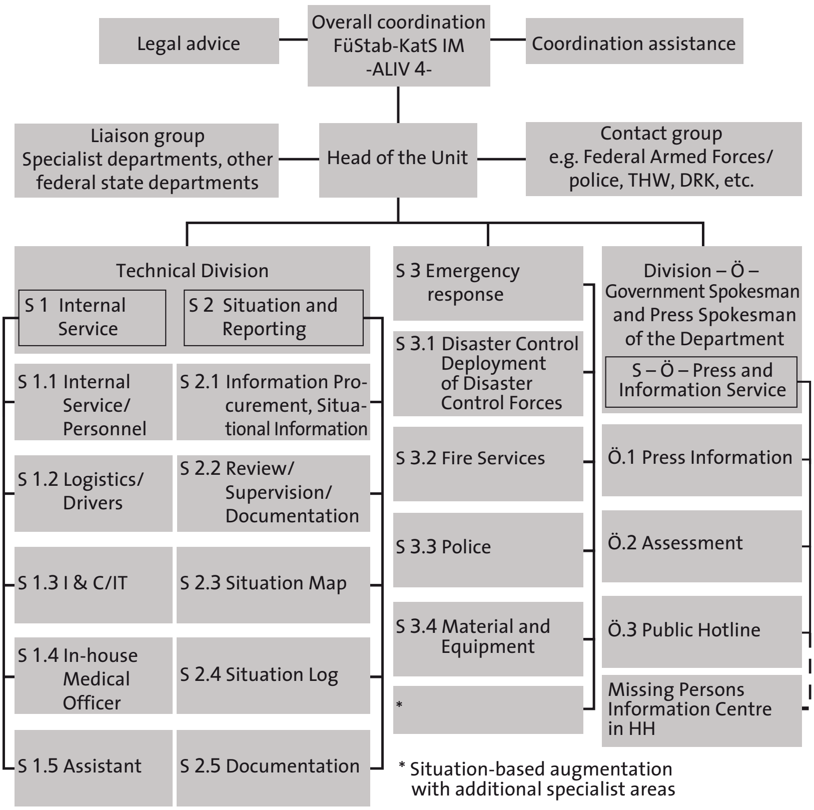
Source: BMI 2010, p. 14 f.

The Inter-ministerial Coordination Group of the Federation and the Länder (IntMinKoGr) plays a key role during a prolonged and widespread power blackout. If the situation is such that the system of cooperation between the cri-

17 deNIS II plus was first used for the LÜKEX 2007 exercise. Its aim was to provide the participating situation centres with an up-to-date picture of the situation (www.bbk.bund.de/nn_401590/DE/02__Themen/11__Zivilschutztechnik/04__Warnsyst/01__SatWas/SatWas__node.html__nnn=true; accessed on 10.5.2010).

sis units proves insufficient, this coordination group can be convened by the Federal Ministry of the Interior (BMI) in order, for example, to arrive at joint situation assessments and recommendations for action, and to ensure coordinated communication between the Federation and the Länder (BMI 2010, p. 16).

FIGURE 5 HIGH COMMAND FOR DISASTER CONTROL OF THE MINISTRY OF THE INTERIOR OF SCHLESWIG-HOLSTEIN



Source: From IMSH 2010, p. 11

Led by the Federal Ministry of the Interior, the Inter-ministerial Panel on National Crisis Management constantly optimises inter-ministerial crisis management. Furthermore, agreements have been concluded that make it possible to call up inter-ministerial joint crisis task forces at the Federal Ministry of the Interior in certain cases.

Due to the varied federal peculiarities, it is only possible to make limited general statements on the structures of crisis units or management units at federal state level. Figure 5 shows the structure of the high command for disaster control (FüStab-KatS) based on the disaster control plan of Schleswig-Holstein. The liaison group and the contact group are of particular importance for widespread situations. The liaison group assumes coordination and communication functions with regard to other departments and subordinate authorities at federal state level. The contact group comprises liaison officers of different players involved in disaster control (e.g. liaison officers of the Federal Armed Forces or representatives of the THW, the fire services or the German Red Cross (DRK)). Its task consists in maintaining and coordinating the operational response (using additional forces and resources where applicable).

The high command is convened by the Ministry of the Interior where this is required by a situation. Its main task is to observe the situation. Acting in a specialist supervisory capacity, it intervenes where necessary in the measures taken by the subordinate disaster control authorities and supports these authorities without, however, assuming actual control (IMSH 2010, p. 11).

AID ORGANISATIONS AND SUPPORT FORCES

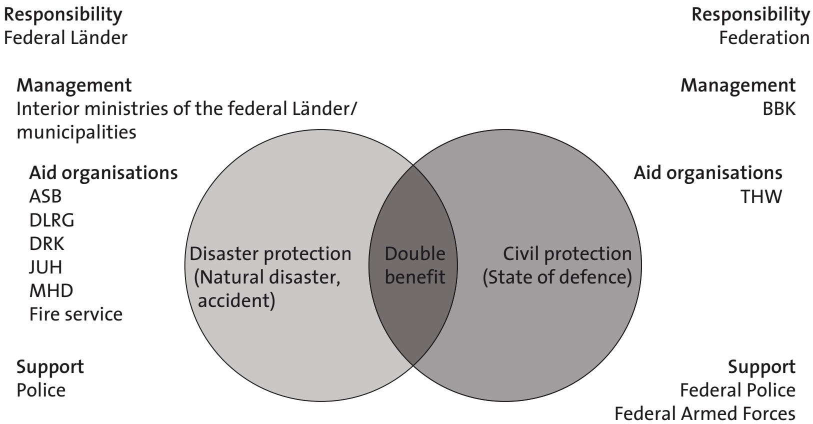
At the operational level of emergency response and management, numerous players become involved at Federal and Länder level when a disaster strikes (Figure 6). The following section examines the police, the THW, the Federal Armed Forces and also the fire services and their coping capacities.

POLICE FORCES

The police forces are made up of different organisations. Alongside the police tactical units, the most important and largest units include the (former) branches of the Constabulary and the Criminal Police Office. Disaster control is not one of the core tasks of the police forces at federal and Länder level. Consequently, no corresponding special organisational units are established and even the quantity and quality of technical equipment are not designed for the requirements of disaster protection.[18] However, in threat situations and major damage scenarios, the police forces are responsible for emergency response and for maintaining safety and order. Police and non-police high commands work together in such cases.

18 Limited quantities of equipment such as lighting systems, transport lorries and power generators are available.

FIGURE 6 AID ORGANISATIONS AND SUPPORT FORCES



ASB: Arbeiter-Samariter-Bund (Workers' Samaritan Federation); BBK: Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (Federal Office of Civil Protection and Disaster Assistance); DLRG: Deutsche Lebens-Rettungs-Gesellschaft (German Lifeguard Association); DRK: Deutsches Rotes Kreuz (German Red Cross); JUH: Johanniter-Unfall-Hilfe (St. John Accident Assistance); MHD: Malteser Hilfsdienst (Maltese Cross Relief Service); THW: Technisches Hilfswerk (Federal Agency for Technical Relief)

Own image

The tasks of the German Federal Police (BPOL) include border protection, tasks of the railway police, protection against attacks on aviation security, police tasks when a state of tension/state of defence exists, supporting the police of the federal Länder especially at times of major deployments and assistance in the event of a widespread and prolonged power blackout including the air rescue service. The BPOL currently has around 40,000 employees; of these, around 30,000 are law enforcement officers.

Cooperation between the BPOL and the federal Länder in the event of disasters or grave accidents is based on Article 35 [2] of the Basic Law (GG) in conjunction with Section 11 of the Federal Police Act (Hiete et al. 2010, D 20).

FEDERAL AGENCY FOR TECHNICAL RELIEF

The Federal Agency for Technical Relief (THW) is responsible for technical assistance in civil protection and disaster control. At the request of the bodies with responsibility for emergency response, it renders administrative assistance pursuant to Section 1 [2] second sentence No. 3; such assistance is mainly rendered in connection with local emergency response in cities and local authorities. Support is given to the fire services and also to emergency medical services or the police in cases involving mass injuries.[19] The THW units report to the local crisis management units.

The following units and power generators are available for managing a power blackout:

- 89 units in the electricity supply section
- 83 units in the infrastructure section
- 140 units in the lighting section
- 5,000 power generators ranging from 5 to 9 kW each.
- 570 power generators ranging from 10 to 99 kW each.
- 140 power generators/emergency power systems of approx. 100 to 400 kW each (THW website a & b)

The THW has more than 80,000 voluntary helpers and around 850 full-time employees. It comprises 8 state branches and 668 local branches. The state branches are the points of contact for the supreme Land authorities and for the state branches of other organisations and bodies. Each local branch is presided over by the local officer who acts as honorary administrator. At the level of individual organisations, the offices of the THW maintain contact with the offices of the Federal Armed Forces and the German Federal Police. The cross-regional deployment of THW teams is coordinated by a team of management and coordination staff within the THW management structure. During operational deployment, this team maintains the necessary contact with other federal teams deployed (BBK 2008b, p. 101).

FEDERAL ARMED FORCES

The Basic Law stipulates that the Federal Armed Forces should primarily be deployed for the external defence of the Federal Republic of Germany. However, Article 35 [1] of the Basic Law (GG) makes it possible for (technical) administrative assistance to be provided, although not through the use of specific (military) resources of the armed forces. In addition, Article 35 [2] of the Basic Law provides for the Federal Armed Forces to be deployed at the request of a federal state in order to assist, for example, in natural disasters or in the event of a particularly grave accident. This must constitute supplementary assistance and must not involve long-term cooperation. If a threat involves more than one federal state then according to Article 35 [3] of the Basic Law, the Federal Government may deploy units of the armed forces to support the police forces.

19 This was the case at the G8 summit in Heiligendamm (2007), where the THW's tasks included securing the power supply, lighting of control areas and operation of assembly areas for security authorities and rescue teams.

The Federal Armed Forces currently comprise around 188,000 full and part-time soldiers, 38,700 basic military service conscripts and 26,500 conscripts on longer military service; around 90,000 reservists are also available, many of whom can also be deployed for disaster control protection tasks within the framework of »civil-military cooperation«. Regular cooperation/relationships between the military commando authorities and the civil authorities should be ensured at all levels of the federal system in order to prepare for deployment in the event of a disaster.

In view of the significant problems arising in the wake of a power blackout, the Federal Armed Forces could, among other things, provide assistance[20] for the civil authorities in the following areas (BMI 2005a, p. 6 ff.):

- Coping with large numbers of injured persons, including in particular with the provision of air transport capacities;
- Providing communications support for the aid organisations and their management;
- Providing engineering and other support, including air transport for people and materials.

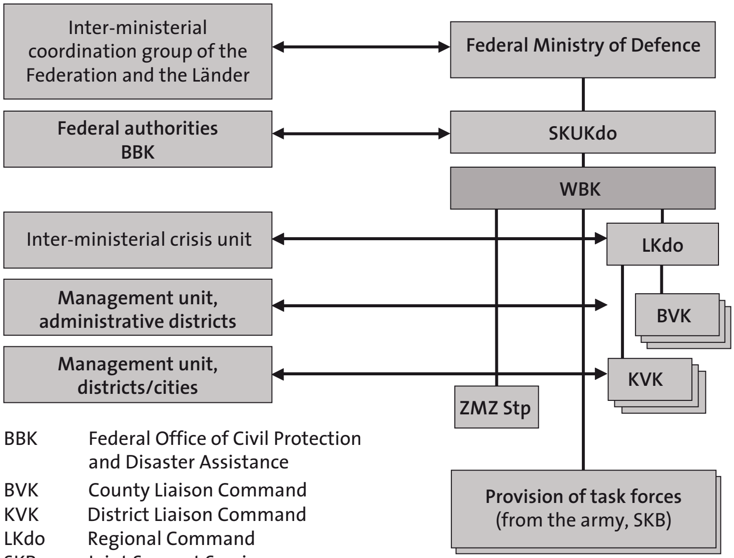
Services such as these are almost entirely based on »resilient resources«. They can be operated on a self-sufficient basis and should be designed for long periods of deployment.

The provision of communications support includes the provision of mobile offices, the establishment and operation of network-independent communications structures (satellite and radio communication) by the signal corps and the provision of liaison personnel for decision-makers and the supporting organisations. According to the Federal Ministry of the Interior (BMI) (2005a, p. 9), a mobile, multi-tiered management organisation (personnel and materials) with network-independent communications connections would be available in the event of a disaster in order to control the deployment of military forces to support the relevant disaster control authorities at local level.

Civil-military cooperation (ZMZ) within Germany and disaster assistance constitute key tasks of the Joint Support Service (SKB). The Joint Support Service is not a branch of the Armed Forces such as the Army, Navy and Air Force, but it does represent an independent military sphere of authority. To fulfil national territorial tasks, the Joint Support Service has a territorial organisational structure, based on military districts, that includes four military districts.

20 The extent to which this is possible in the light of the increasing obligations incumbent on the Federal Armed Forces in connection with international missions cannot be determined here (see, for example, Rechenbach 2005, p. 159).

FIGURE 7 TERRITORIAL NETWORK OF THE FEDERAL ARMED FORCES FOR CIVIL DISASTER CONTROL



BBK	Federal Office of Civil Protection and Disaster Assistance
BVK	County Liaison Command
KVK	District Liaison Command
LKdo	Regional Command
SKB	Joint Support Service
SKUKdo	Armed Forces Support Command
WBK	Military District Command
ZMZ Stp	Civil-military cooperation base

Source: Streitkräftebasis 2007

In a disaster scenario prompted by a power blackout, the Armed Forces Support Command (SKUKdo) could be the national joint operations command for the Bundeswehr forces deployed in the territory of the Federal Republic of Germany. The Regional Command (LKdo) that advises the Land governments in matters relating to disaster control works in the crisis unit of the federal state affected by the disaster. Liaison commands exist at the subordinate echelons (administrative regions, counties and county boroughs) within the framework of civil-military cooperation.[21] These commands communicate with authorities and organisations concerning possible assistance by the Federal Armed Forces. They are manned only by regionally based reservists who can be called up immediately in the case of a mission. When not involved with missions, the head of a liaison command also acts as contact person for the local authorities on matters

21 31 district and 426 county liaison commands have been established with around 5,500 reservists (BBK 2008a, p. 33).

relating to disaster control. This concept creates a »geographical congruence of civil and military structures« (Lüder 2009, p. 144).

The Federal Armed Forces only provide assistance following a request by the competent civil authorities. The higher command authorities (Armed Forces Support Command (SKUKdo), Military District Command (WBK)) decide on the type and extent of support, in consultation with the management commands of the organisational sectors planned for the mission. At the operations site, the Federal Armed Forces teams report to the competent WBK commander regarding fulfilment of their duties. The officer with responsibility for local operations takes instructions from the competent (civil) disaster control authority. The length of the operations by the Federal Armed Forces is limited to the time for which no other adequate operations and assistance teams are available (BMVg 2008).

FIRE SERVICES

Fire services comprise professional fire brigades, voluntary fire brigades and works fire brigades. They cover the largest area of all emergency response organisations. The voluntary fire brigade alone had around 1,039,000 active members in 2007 (Table 1).

TABLE 1 NUMBER OF FIRE BRIGADES IN GERMANY AND THEIR MEMBERS (2007)

Number of …	Professional fire brigades	Voluntary fire brigades	Works fire brigades
Fire brigades	100	24,410	982
Members	27,816	1,039,737	32,752

Source: Deutscher Feuerwehrverband 2009

Much of the fire services' equipment is geared to the requirements of disaster control. They have key material resources in the form of vehicles, rescue equipment and communications facilities to ensure they can carry out operations at local level even in difficult conditions. However, some complaints are voiced that insufficient investment by those responsible for fire protection means the material equipment of some fire brigades is still inadequate (Rechenbach 2005, p. 162). Out-dated equipment and long response times make it more difficult to accomplish tasks effectively.

It is said that to date, the system of crisis management in Germany as described above has »never reached its limits« (Unger 2008, p. 100). The two following chapters (Chapters III and IV) aim to examine, as far as possible, if this would also apply in the event of a prolonged and widespread power blackout.

CONSEQUENCES OF A PROLONGED AND WIDESPREAD POWER BLACKOUT III.

INTRODUCTION 1.

The main aim of the TAB project was to analyse the vulnerability of critical infrastructures in the event of a prolonged power blackout affecting several federal Länder. This was done by conducting consequence analyses of selected critical infrastructure sectors (see Chapter I.3 for a discussion of the selection process and associated reasons). Some hypotheses are developed concerning possible attitudes and patterns of behaviour by the population affected by the blackout. The findings are documented in this chapter (Chapter III.2 and III.3). This is preceded by comments on the possibility and likelihood of a prolonged power blackout extending across regions and also on the costs of such a blackout (Chapter III.1.1 and III.1.2).

COMMENTS ON THE CAUSES OF A PROLONGED AND WIDESPREAD POWER BLACKOUT 1.1

The stipulated aim of the TAB project was to study the »consequences« of a prolonged and widespread power blackout – not its causes. Despite this restriction, possible causes and probabilities of such a blackout occurring[22] were examined in order to clarify whether such a serious power blackout as assumed in the TAB's mandate could actually occur.

So what are the possible and plausible causes? The list of possible threats caused by either nature or human beings is long, but not all result in a prolonged power blackout. Reichenbach et al. (2008, p. 20 ff.) list some of the causes as technical and/or human failure, criminal or terrorist acts, an epidemic/pandemic or climatic events such as storms, snow and ice or floods.

- Technical/human failure could result in serious disruptions to network management and network control processes.
- An organised criminal act results in significant damage to technical infrastructures within the distribution network.
- A serious natural event (heavy rain with flooding, storms, heavy snow, ice storms) could result in an extensive power blackout.

22 BMI/BBK (2007) identified up to 300 possible threats as potential causes.

- A pandemic results in a large number of people falling ill; employees remain at home to look after their relatives. This could also result in a prolonged power blackout.

As well as being perfectly plausible in terms of current framework conditions for power generation and supply, this risk assessment is also relevant for any future changes. These include the following developments, among others (BMI/BBK 2007, p. 92 f.)

- An increase in decentralised, stochastic current feed in connection with an expansion of commercial activities increases the risk of network failure and higher blackout rates.
- Germany could increasingly become a target for attack by terrorist groups planning a well-prepared attack on power supply facilities.
- Climate change could result in more and more severe extreme weather events.

Overall, there are good grounds for assuming that the likelihood of a power blackout will increase in future (BMI/BBK 2007, p. 180).

However, given the current framework conditions and structures for the electricity supply system and also the relatively high resilience of the overall system, it can be assumed that a prolonged and interregional power blackout would require the physical destruction of key components that are difficult to replace in several power stations (e.g. the turbine generator set) or in the transport network (e.g. transformers) (Prognos 2009, p. 7). Even when considered from the point of view of the power supply companies, »several very specific elements would have to malfunction or be destroyed« in order to lead to substantial or even catastrophic damage (BMI/BBK 2007, p. 94 and 178).

A fictitious but sufficiently plausible causal scenario is provided for illustration purposes: As a result of targeted, surprise campaigns, a fire starts simultaneously in the generator transformer[23] of several power stations in Germany; numerous transformers are destroyed and rendered unusable.[24] This triggers a power failure across large parts of Germany. After around 24 hours the relevant persons with responsibility at local level and in the central crisis units of the utility companies and also the authorities[25] become aware that the power blackout could last a few weeks.[26]

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23 A generator transformer forms part of a power station and transforms the voltage created in the electrical generator into high voltage, which is then fed into the grid by means of trunk lines. The transformers are generally located in the outer section of a power plant.

24 Among the »critical elements« that could seriously jeopardise the electricity industry, the joint report by the BMI/BBK (2007, p. 78) mentions the simultaneous failure of »several large power stations«.

25 In such a situation, responsibility for managing the risks resulting from the specified activities initially lies with the police and fire service until a disaster is pronounced; thereafter, the disaster control authorities are responsible. However, in cases such as

For the purposes of the consequence analyses, no further framework conditions are defined regarding the details of the power blackout. However, some of the sector analyses do examine specific parameters of the event context where this is relevant for a differentiated assessment of the situation or for an appraisal of events and measures. This applies, for example, to contextual factors such as the time of day (whether the blackout occurred during the day or night), the time of year (summer or winter) and regional peculiarities (rural areas, densely populated areas, topography).

COSTS 1.2

Experience of previous national and international power blackouts reveals that a prolonged power blackout entails significant costs. These are incurred as a result of primary damage to people and property and also as a result of additional commercial and economic consequential damage arising due to delays and breakdowns in services and within manufacturing. These will extend far beyond the actual damaging event.

However, the damage caused by a blackout is difficult to assess in economic terms. For example, a number of factors determine the amount of costs incurred as a result of a power blackout. According to Böske (207, p. 46 ff.), the following factors determine the amount of the costs associated with a power blackout:

- Type and extent of consumer groups affected (e.g. households or industry),
- Frequency and predictability of power blackouts,
- Duration of the power blackout
- Extent of the power failure,
- Regional conditions (e.g. climate, structure of industry),
- Timing of the blackout (e.g. day or night, summer or winter),
- Source of the blackout (e.g. a power station or the distribution network).

However, customary methods only consider some of these parameters. The price per kilowatt hour that cannot be supplied is often used as a monetary measure of the damage caused by a power blackout (Bliem 2005, p. 6; Böske 2007, p. 45). The costs incurred on the generator side are the direct consequence of damage to technical equipment and of the amount of electricity that can't be sold as a result. By contrast, costs incurred by consumers are significantly more difficult to quantify because only some of these costs are incurred as a direct result of the inability

this, these players from non-police emergency response organisations will work closely with the police (Paul/Ufer 2009, p. 128 f.).

26 The exercise for LÜKEX 2004 was based on a power blackout affecting the regions of the federal states of Bavaria and Baden-Württemberg and lasting for several weeks (Grambs et al. 2006).

to supply a quantity of electricity. For example, households incur direct costs through damage to equipment and electrical devices and as a result of goods perishing. Non-monetary costs are also incurred through the loss of leisure time. Companies incur financial losses due to the interruption to the value creation process (Bliem 2005, p. 7 and 8; Bothe/Riechmann 2008, p. 32 and 34).

Various methods are used to estimate the costs of a power blackout:

- Blackout studies determine costs following a power blackout by assessing the monetary value of all effects and adding these together. However, focussing on one case study makes it difficult to generalise and transfer the findings.
- Macroeconomic methods use statistical data to make highly simplified assumptions on the costs of lost production and reduced leisure value as a result of the blackout. However, direct damage (e.g. to facilities) is not considered.
- Surveys based on questionnaires or interviews are designed to determine the willingness of end consumers to pay to avoid a power blackout (e.g. Carlsson et al. 2009). Other surveys consider the compensation requirements of end consumers in the event of a disruption to supplies. Disadvantages of such methods include the difficulties encountered by end consumers in quantifying possible damage and in the response behaviour of those surveyed (Bliem 2005, p. 6; Böske 2007, p. 45; Bothe/Riechmann 2008, p. 34).

Previous studies on real or notional power blackouts are generally based on one of the above methods and have, for example, arrived at the following assessments:

- On 14 August 2003 a power blackout in North America spread over eight states of the USA and parts of Canada, affected over 50 million people and lasted for up to 3 days (Public Safety Canada 2006). The financial consequences were determined by a study based on a survey of end consumers' willingness to pay to avoid a power blackout. The willingness to pay was put at one hundred times the price of 1 kWh of electricity. Multiplying this figure with the number of people affected and the average length of the blackout gave an amount of between 6.8 and 10.3 billion US dollars (ICF Consulting 2003, p. 2). A blackout study that estimates the costs at 4.5 to 8.2 billion US dollars arrived at a similar result (Anderson/Geckil 2003, p. 3).[27]
- A macroeconomic analysis was conducted to assess the costs of a possible power blackout in Austria. This study calculated the value of a kilowatt hour of electricity not supplied by creating a relationship between electricity consumption and value creation, with work time and leisure time considered on

27 The derived values are not, however, conclusive and some values differ from those used in the calculation. Even without taking additional costs into account, the loss of income (set at 4.2 billion US dollars) and the damage to power companies' equipment (estimated as at least 1 billion US dollars) exceed the minimum estimate (Anderson/Geckil 2003, p. 2 ff.).

an equal basis. This produced a value of 8.6 euros per kilowatt hour of electricity not supplied. Based on this, the cost of a one-hour power blackout in Austria was calculated as between 40.6 and 60.1 million euros depending on the time of day and the day of the week when a blackout occurs (Bliem 2005, p. 2, 7 and 17).

› The economic consequences of a power blackout in Germany have also been calculated in a meta study. This study derived the costs of a power blackout from 25 international studies, taking into account the current intensity within German industry. According to this study, each kilowatt hour lost results in costs of 8 to 16 euros. Transferred to a scenario involving a one-hour power blackout across Germany on a working day in winter, this would result in economic damage of between 0.6 and 1.3 billion euros (Bothe/Riechmann 2008, p. 33 and 35).[28]

Information such as this and previous studies into the costs of a power blackout provide an indication of the significant monetary damage that can ensue following a power blackout (e.g. Silvast/Kaplinsky 2007, p. 32 f.). It can be assumed that a scenario of a power blackout lasting several weeks with a number of secondary consequences and effects on other critical infrastructures is likely to entail additional direct costs; these would probably rise exponentially after a short time (Steetskamp/van Wijk 1994, p. 8). Later costs of rectifying damage and successive re-commissioning of all processes within industry and society must also be taken into account. Also, it is important not to overlook intangible damage such as the public's loss of confidence in the power supply companies or in the authorities.

Looking beyond economic aspects, however, it is also necessary to consider the social costs of a power blackout that brings disastrous consequences. These include a failure of the political/administrative system and a collapse of social organisation and solidarity – if the disaster cannot be managed as a »blatant form of social change« (Clausen 2008, p. 15).

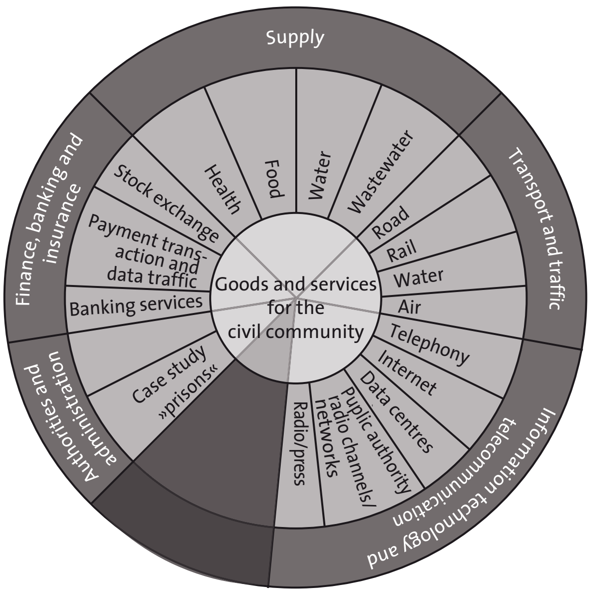
CONSEQUENCE ANALYSES OF SELECTED CRITICAL INFRASTRUCTURE SECTORS 2.

This chapter presents and discusses the results of the consequence analyses for seven critical infrastructure sectors. The sectors considered included three »basic technical infrastructures« of »information technology and telecommunications«,

28 Information on costs can also be found in numerous other sources: According to the »Green Paper«, the power blackout in the Münsterland region that lasted for several days in 2005 caused damage amounting to around 130 million euros. However, no details are provided on how this amount was determined (Reichenbach et al. 2008, p. 19).

»transport and traffic«, also »water supply and wastewater disposal«, along with four »socio-economic service infrastructures« of »food supply«, »health«, »financial services« and a case study on »prisons« (BMI 2009, p. 8) (Figure 8).

FIGURE 8 SECTORS AND CHALLENGES EXAMINED



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In a disaster situation such as a prolonged power blackout spanning several regions, the degree of vulnerability and level of resilience of critical infrastructures is ascertained by whether people's elementary needs such as food and drink can be satisfied, whether necessary medical care and a minimum standard of hygiene can be ensured, and also whether at least rudimentary options in terms of mobility, paying for essential purchases or services and – very importantly – in terms of information and communications can be established (Chapter III.2.1 to III.2.6). Finally, public institutions and buildings and their functions within the community are jeopardised. For example, if it is not possible to guarantee a comprehensive level of public safety and security, people's confidence in the state and its organs would be shaken to the core. In this context, the report examines the case study of »prisons« (Chapter III.2.7).

As a supplement to these analyses, the report discusses the question of how individuals and groups would behave in the event of a (prolonged) power blackout. Since there is hardly any scientific literature on the subject, the report develops and discusses hypotheses; in some cases this is done by drawing on findings on behaviour in other types of disaster (Chapter III.3).

The individual sector analyses have a largely identical structure. Following an introductory outline of the sector's structural and legal characteristics, the report presents the consequences and chains of consequences that could follow as a result of a power blackout.

This presentation of the consequences is largely based on time segments (e.g. 0 to 2, 2 to 8, 8 to 24 hours). It generally covers a maximum period of 8 to 10 days and in some cases looks forward to the second week following the blackout. The analysis ends at this point because the accumulation of internal problems combined with the consequences of breakdowns in interdependent sectors has already led to a catastrophic situation.

Using a narrative form in some cases (as in the case of the transport sector and the supply of food and health provision), examples are provided showing possible consequences and secondary consequences. Other configurations and effects are equally possible and their probability and plausibility need to be considered. The course of the presentation follows one strand and therefore provides only a snapshot of the area under consideration, i.e. the report does not endeavour to offer a systematic or complete approach.

This method is designed to encourage an insight into various aspects: What are the structures of the sector in question? What players are involved and who are the people affected? What processes are conceivable and possible? Where do responsibilities lie? What laws, statutory instruments and plans are used as a basis for action? Which resources are available for disaster management (and which are not available)? What about the resilience of the individual sectors? Gaining insights also means identifying gaps in information and areas where knowledge is lacking and also noting these if they cannot be remedied. This was often the case. At this point it should therefore be emphasised that some of the results of the sector analyses do harbour major uncertainties.

INFORMATION TECHNOLOGY AND TELECOMMUNICATIONS 2.1

As in many other countries (Schulze 2006, p. 114), information technology (IT) and telecommunications (TC) are considered critical infrastructures. According to the BSI, both the IT/TC sector in itself (the major IT/TC networks with their components and operators) and also the IT/TC-based infrastructures of other sectors represent critical information infrastructures: »Information technology and telecommunications form a separate infrastructure sector but also describe a transverse infrastructure on which all other sectors depend.« (BSI n.d.) The structures, networks and components of the sector enable location-independent communication, fast data transmission and also process control and optimisation. The most important means for transmitting information include fixed-network telephony, two-way radio, radio broadcasting, mobile telephony services and the Internet (BSI, n.d.).

To start with, the following section examines some structural characteristics of the »information technology and telecommunications« sector. This is followed by statements on the legal bases and political responsibilities. Following this there is a discussion on whether the information technology and telecommunications sector constitutes a special infrastructure. Finally, the knowledge on the consequences of a widespread and prolonged power blackout for information technology and telecommunications is examined. The chapter ends with a conclusion. All statements apply to use by private individuals. The framework conditions and technologies applicable to the authorities and also to emergency and support forces are considered in Chapter IV.1.

STRUCTURAL CHARACTERISTICS 2.1.1

Different approaches can be used when determining the structure of this sector; these include hardware and software or data and media types.

HARDWARE AND SOFTWARE

Technically speaking, the IT infrastructure (Patig 2009) comprises hardware and software and also the structural facilities for their operation. With hardware, it is important to distinguish between computing and storage technology, network technology, peripheral devices or terminal equipment and also the equipment for operating the hardware.

It is necessary to differentiate the field of (telecommunications) network technology still further in order to consider its susceptibility to breakdown/the consequences of breakdowns. In extremely simplified terms, it is possible to distinguish between international and national wide area networks (backbone networks) and access networks. Often, there are more than these two levels of network hierarchies – access network and wide area network – that need to interact and between which relevant switching nodes exist.

It is also important to remember that data centres are needed to enable the use of communications services; these are required not only for processing the relevant communications service but also for purposes relating to, for example, access authorities and usage tracking for billing purposes.

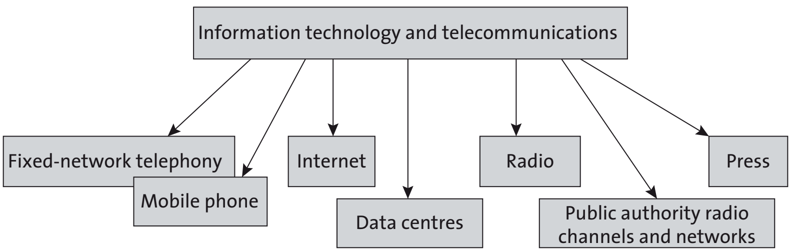
Switching and transmission can be either cable-based (e.g. in the case of fixed-network telephony) or cable-free (e.g. mobile telephony, directional radio, data transmission via satellite). Both transmission methods – which can also be further differentiated – are not fully distinct from one other; in some cases they are used in combination depending on access and network level.

DATA AND MEDIA TYPES

The information technology and telecommunications services sector can also be structured according to data or media type. A distinction is made between voice and data services. Data services are divided into texts, static (graphics, photos) and dynamic (music, sound, film, animation) media and also data and software. The move towards general digitalisation means these previously very strict distinctions are now much softer. In principle, all information technology and telecommunications infrastructures (including the Internet) are able to transmit every (digitalised) media format. However, the trend towards convergence has not progressed to such an extent that it is no longer possible to distinguish dominant contours.

Figure 9, which shows the sub-sectors of the information technology and telecommunications sector that are considered in further detail in the remainder of this chapter, is based on traditional distinctions and does not generally consider the overlaps at service level (»convergence«).

FIGURE 9 STRUCTURES OF THE »INFORMATION TECHNOLOGY AND TELECOMMUNICATIONS SECTOR«



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LEGAL BASES AND POLITICAL RESPONSIBILITIES 2.1.2

LEGAL BASES 2.1.2.1

Article 87 f [1] of the Basic Law stipulates that in the field of postal services and telecommunications, the Federation must guarantee appropriate and adequate services across Germany. It is argued that from these basic rights, it can be inferred that the state must also ensure that people can make use of the basic rights. However, since this also largely depends on functional critical infrastructures, it also becomes evident that the state has an obligation to protect these infrastructures (BSI 2005, p. 7 f.)

At the level of ordinary law, the first act to mention is the Telecommunications Act (TKG). Part VII places special emphasis on preventive obligations on the part of operators (e.g. to guarantee emergency phone calls) (Section 108) or as regards providing technical protective measures (Section 109 [2]). According to these provisions, suppliers who provide telecommunications services for the public must »take appropriate technical precautions or other measures to protect against breakdowns that cause significant disruption to telecommunications networks and to protect against external attacks and the effects of disasters«.

In addition, the Law Concerning the Transformation of the Deutsche Bundespost Enterprises into the Legal Structure of Stock Corporation (PTSG), the Ordinance ensuring the Provision of Telecommunications Services (TKSiV) and the Ordinance on Civil Protection for Post and Telecommunications Services (PTZSV) are also of relevance for managing the consequences of a significant disruption to telecommunications.

The aim of the PTSG is to »ensure the adequate provision of postal and telecommunications services in the event of a natural disaster or a particularly grave accident, within the context of emergency response on the basis of international agreements, within the context of cooperation with the United Nations, within the framework of alliance commitments and when a state of tension/defence exists.« The Act[29] applies to the former state-owned enterprises Deutsche Post AG and Deutsche Telekom AG and to other companies within this sector (Section 2). Among other things, the Act provides for statutory instruments or orders by the Federal Ministry of Economics and Technology (BMWi) to ensure priority access for certain administrative authorities (Section 3 [3]), obligations concerning the provision of information (Section 4), participation in contingency planning (Section 5), participation in working groups and participation in exercises (Section 6).

The two aforementioned ordinances provide firmer details for these statutory regulations. For example, in Section 2, the TKSiV states the minimum level of telecommunications services that must be guaranteed in the event of a crisis or disaster. This includes:

29 In October 2010 the Federal Government submitted a Draft Act on Re-regulation of the Post and Telecommunications Safeguarding Law and Amendment of Provisions Relating to Telecommunications Law (Bundesregierung 2010). Among other things, the Act aims to place greater emphasis on cases involving major disruptions to supplies.

1. Switched telephone service connections, including mobile telephone service,
2. Switched connections in the Integrated Services Digital Network (ISDN)
3. Establishment of telephone connections including wireless telephone connections,
4. Establishment of ISDN basic rate connections,
5. Establishment of fixed connections (analogue, 64 kbit/s, 2 Mbit/s),
6. Establishment of transmission paths for transmitting sound and television signals and
7. Clearing faults in the telecommunications services listed under 3 to 6 above.

The administrative authorities who must be guaranteed priority access to telecommunications services include the following (Section 4):

- Federal authorities,
- Land, county and municipal authorities,
- Disaster control and civil protection organisations,
- Administrative authorities in the health sector,
- Emergency and rescue services
- Offices of the Federal Armed Forces and of forces stationed in Germany,
- Press and broadcasting operators,
- Public telephone system service providers,
- Operators of telecommunications facilities, where this is required for fulfilling the obligation pursuant to Sections 2 and 3, and
- Suppliers of telecommunications services, where this is required for fulfilling the obligation pursuant to Sections 2 and 3.

In addition, emergency numbers of public telephone services must be accessible to everyone without restrictions (Section 4 [2]).

The Law Concerning Amateur Radio Service (AfuG) also deserves mention here. Section 2 defines an amateur radio service as a radio service that can be used, among other things, to support assistance measures in emergency and disaster situations. Section 5 expressly provides for an exemption to the ban on transmitting messages to third parties (who are not amateur radio enthusiasts) in emergency and disaster situations. This does not infer the possible use of amateur radio by the state in the event of a crisis; however, the more general standard of Section 323 c of the Penal Code (failure to provide assistance) could apply in such cases and justify an obligation for amateur radio enthusiasts to provide communicative assistance in a disaster situation.

BSI (2005, p. 33) makes a critical observation that although relatively detailed and differentiated regulations exist concerning protection against conventional threats in the field of telecommunications, protection against IT-specific threats (»cyber-attacks«) is only regulated on a very generalised basis. Moreover, it is argued that there is a total absence of corresponding statutory obligations on operators in the field of telemedia and multimedia services. This is considered particularly problematic for the domain name system, which is a key placement service for the Internet; this is because for the Internet, smooth functioning of the domain name system is equally as important as the integrity of the telecommunications infrastructure.

An additional point of criticism concerning the existing legal contingency measures is that current laws and ordinances do not give sufficient consideration to a scenario involving a prolonged and widespread power blackout. The statutory requirements for crisis prevention are so generalised and unspecific that it is not possible to derive any specific requirements for such an emergency.

POLITICAL MEASURES AND RESPONSIBILITIES 2.1.2.2

The Inter-ministerial Working Group on Critical Infrastructures (AG KRITIS) was established on the initiative of the Federal Ministry of the Interior in 1997.[30] Even after this working group was disbanded in the year 2000, the Federal Ministry of the Interior remained responsible for the protection of critical infrastructures.

At the same time as the AG KRITIS was formed, a Critical Infrastructures Division was established within the BSI. One of this division's tasks was to carry out preliminary work for the AG KRITIS and in 2002 it submitted a series of studies on individual critical infrastructure sectors; these studies are not, however, available to the general public. Among other things, the division analyses the criticality of the different infrastructure sectors – mainly in terms of IT security. Another key area of its work involves cooperation with both industry and science. Following reorganisation of the BSI in 2005, a separate research section Security in Critical Infrastructures and in the Internet was established; this has both technically oriented divisions such as the Computer Emergency Response Team of the Federal Administration (CERT-Bund) and also a Critical Infrastructures Division, which deals more with policy and strategy.

Following the terrorist attacks in the USA in 2001, the Critical Infrastructures Project Group (PG KRITIS) was established in 2002. The Group included several divisions of the BMI and also representatives from the BSI, the BBK/its predecessor organisations, the BKA and the THW. The project group was tasked with coordinating activities for the protection of critical infrastructures and of preparing an integrated national concept.

30 The following discussion is based on Schulze (2006, p. 155 ff., 185 f., 205 ff.). In this context, it is also worth mentioning the fourth report of the Study Commission of the German Bundestag on the »Future of the Media in the Economy and Society – Germany on the Way to the Information Society« (Enquete-Kommission 1998), which also addressed the issue of the IT security of infrastructures.

In 2005 two political documents were published, each under the aegis of the BMI; these pooled previous activities and provided a basis for future work. These documents were the National Plan for the Protection of Information Infrastructures (NPSI) and the Baseline Protection Concept for the Protection of Critical Infrastructures (BMI 2005b and c). While the Baseline Protection Concept does not have a specific IT focus and primarily aims to serve as a tool for heightening the awareness of private commercial operators of critical infrastructures with regard to the subject and for adopting necessary measures, the NPSI's main focus is on the security of the information infrastructure. Around this time the Project Group on Communication and Security (PK KS) was also set up within the BMI (Helmbrecht 2006, slide 6); this project group replaced the PG KRITIS. The Baseline Protection Concept was updated and enhanced in 2008 (BMI 2008). It is designed as a guideline for the operators of critical infrastructures (either private enterprises or authorities), and provides assistance in the development and enhancement of their respective risk and crisis management systems.

The Federal Cabinet adopted two implementation plans in relation to the NPSI in 2007. The first plan was an internal IT security guideline for the Federal Administration entitled Implementation Plan for Ensuring IT Security in the Federal Administration (UP Bund), while the second one was the Implementation Plan for Critical Infrastructures (UP-KRITIS) (BMI 2007), which sets forth security objectives and other steps in cooperation with industry. Among other things, four working groups dealing with emergency and crisis exercises, crisis response and management, maintenance of critical infrastructure services and national and international cooperation were established; some of these working groups have already submitted reports.

In accordance with the TKG and PTSG, the Federal Network Agency assumes certain tasks pertaining to the resilience of the telecommunications infrastructure; these tasks are undertaken within the framework of the Emergency Services Access Ordinance (NotrufV) based on Section 108 of the Telecommunications Act (TKG) or with regard to registering authorised parties within the telecommunications and post sector on the basis of the TKSiV (Bundesnetzagentur 2008 and 2010a). The Federal Network Agency does not appear to deal with any political/strategic aspects of critical infrastructures.

A SPECIAL INFRASTRUCTURE? 2.1.3

The following section first examines the special characteristics of the »information technology and telecommunications sector« on a generalised level. Chapter III.2.1.4 then considers the consequences of a prolonged and widespread power blackout in its individual sub-sectors.

In particular, the »IT/TC« sector differs from other infrastructures due to the following factors:

- (almost) 100 % reliance on electricity,
- extensive interdependencies with almost all other critical infrastructures and
- a high level of criticality.

With regard to the sector's framework conditions, it is important to mention:

- convergence
- far-reaching changes in underlying socio-economic conditions and
- fast-moving innovation.

RELIANCE ON ELECTRICITY AND INTERDEPENDENCIES 2.1.3.1

It is impossible to imagine information technology and telecommunications without a power supply. Although the other infrastructure sectors examined as part of the TAB project rely on a power supply, they do not depend on it to such a high degree. During a power blackout a doctor may not be able to read health fund chip cards within his surgery, operate the surgery's computer or take any X-rays. In many cases, however, he can still examine patients, make diagnoses and suggest treatments even if no power supply is available. Similarly, emergency wells can be used to maintain a limited water supply if the power supply fails (even if the electrical pumping systems are no longer able to produce the required water pressure in the water supply network). With the transport system, electrically-driven rail transport stops working, but petrol and diesel-driven traffic or cycle traffic still enable the population to remain mobile.

By contrast, computer-based information processing and electronic communications (as, for example, in the case of radio, television, telephone, the Internet) are not possible without a power supply. Certain alternatives such as personal and direct conversations, pagers or written notices can be used. However, these substitutes obviously cannot ensure synchronous and direct remote communication or indeed prompt communication to the masses.

As revealed by the dependence analyses conducted by the Swiss Federal Office for Civil Protection (BABS 2009, p. 10), a total failure of the power supply sub-sector that lasted for 3 weeks would lead to »extremely major« (the maximum possible rating) consequences for all sub-sectors of the information and communications technologies sector (ICT) (i.e. telecommunications, the Internet, instrumentation, automation and surveillance systems as well as broadcasting and media) (Table 2).

However, the »information technology and telecommunications« sector's dependence on the power supply is not unilateral, but mutual. The power supply system itself (along with other critical infrastructures) also relies on functioning information and communications systems. As revealed by the analyses conducted in Switzerland by BABS (2009, p. 10), the sub-sectors of telecommunications and surveillance systems have a »major« direct impact on the power supply sub-sector (rated »2« on a scale of 0 to 3). Following behind the power supply sub-sector with 68 points, the sub-sectors of telecommunications and information systems and networks (each with 45 points out of a possible 93) have the highest direct impact on all other sub-sectors of Swiss critical infrastructures.[31]

TABLE 2 DEPENDENCIES OF THE SUB-SECTORS

Malfunction of sub-sector ➔ / Impact on sub-sector ➔	Power supply	Telecommunications	Information systems and networks
Power supply	–	2	1
Telecommunications	3	–	3
Information systems and networks	3	2	–
Internet	3	3	3
Instrumentation, automation and surveillance systems	3	3	3
Broadcasting and media	3	2	3
on all 31 sub-sectors	68	45	45

The dependencies of the 31 sub-sectors on each other were rated on a four-stage scale from 0 (no impact) to 3 (very major impact) – assuming a total power blackout lasting for 3 weeks and affecting the whole of Switzerland.

Source: BABS 2009, p. 10, extract from Figure 4

CRITICALITY 2.1.3.2

The criticality of a critical infrastructure refers to its importance in terms of the consequences that breakdowns, loss of functions or destruction have for the safe supplying of society with important goods and services. BABS (2009, p. 8 f.)

31 An interesting attempt to model such multifarious, complex dependencies between critical infrastructures and to record these dependencies on an empirical basis was presented by Chang et al. (2007). Using the example of the ice storm in Canada in 1998 and the associated power blackout that lasted for several weeks in some regions, they examined the effects and interactions on the different infrastructure sectors. The empirical analyses aimed to ascertain the degree to which society was affected in individual areas. In terms of »impact« (duration and intensity of the consequences), the disruptions to the telecommunications sector tended to reveal low to average index values, while very high index values were recorded as regards »extent« (size of the area affected and degree to which the population was affected) (Chang et al. 2007, p. 356).

rated (relative) criticality in three dimensions: effects on other sub-sectors (dependencies), effects on the population and effects on the economy. Thus, while including the dependencies outlined in Chapter III.2.1.3.1, it also extends beyond these. The analysis is again based on a four-stage scale from 0 (no impact) to 4 (major impact).

Here, too, three of five sub-sectors were given the highest criticality ratings: Telecommunications received the maximum possible rating of 9, while information systems and networks and also the Internet each received a rating of 7. Only three other sectors (out of a total of 31) received similarly high criticality ratings; these were the power supply (9), road transport (8) and banks (7).

CONVERGENCE 2.1.3.3

Technological development over the last 50 years has often been described as convergence and has resulted in many overlaps between what were, previously, largely separate communications systems. This applies in particular to telephony, data communications and radio broadcasting. It is no longer possible to assign a network infrastructure to a specific service.

For many years, a broadband cable connection could only be used to disseminate television and radio; now, however, this technology can also be used for telephony and data communications via the Internet. To give a second example, modern transmission technologies now allow broadband Internet and even television transmissions via what were previously narrowband telephone cables. On the one hand, this extensive intermeshing of systems creates greater complexity with more operators and thus increased vulnerability in terms of breakdown. However, it also offers greater variability in terms of usage, which at the same time leads to greater service reliability because in principle, more alternative technical options are available for using a service. If the fixed network telephone system fails, it is conceivable that mobile telephones or Internet telephony (e.g. Voice over IP, VoIP) could be used instead. Further studies are needed to examine where this »convergence« ultimately leads to a merging of the separate systems and thus to new »bottlenecks« and »points of contact«.

PRIVATISATION, DEREGULATION, LIBERALISATION 2.1.3.4

Alongside the increasing convergence due to extensive digitalisation, this sector has also experienced political and economic changes in terms of privatisation, deregulation and liberalisation.

As part of the second reform of postal services, the telecommunications branch of Deutsche Bundespost was privatised in 1994 and floated on the stock exchange in 1996; the Telecommunications Act (TKG) of 1996 abolished the monopoly for telecommunications services, especially fixed-network telephony.

Today, there are almost 3,000 telecommunications suppliers (status: 19 May 2010, Bundesnetzagentur 2010b) compared with only one state-owned monopolist 20 years ago. Up to the 1980s, radio broadcasting only boasted the public broadcasting stations of ARD, ZDF and Deutschlandfunk. The cable pilot project in Ludwigshafen in 1984 marked the starting point for the registration of private television broadcasters in Germany; these were followed by private radio broadcasters in 1986. The Working Committee of Land Media Organisations (ALM) today estimates there are around 450 private and public-law television channels (status: November 2009; ALM 2009) and 223 private radio services (status: 2006; ALM n.d.).

The consequences of these far-reaching changes are more problematic in terms of critical infrastructures because the privatisation of previously state-owned sectors/the expansion of a private sector makes it more difficult for the state to stipulate direct requirements in terms of contingency measures for a crisis scenario. Even if there is voluntary cooperation between the state and industry, which is an important component of the government's policy on protecting critical infrastructures (BMI 2005b, p. 8; BMI 2009, p. 3), it makes a difference whether such contingency measures have to be agreed and implemented with just a few companies or with several hundred companies.[32]

PACE OF TECHNOLOGICAL INNOVATION 2.1.3.5

Information and telecommunications technology tends to be characterised by rapid technological innovation. This also affects the degree to which this sector depends on the power supply. Consider, for example, the degree to which the development of more efficient batteries has made mobile phones and laptops less dependent on a grid-based power supply. Also of relevance in this connection are the discussions on increased demand for electricity due to the use of information technology (Baer et al. 2002), on energy-efficient information technology (»green IT«) and on possibilities for a decentralised, network-independent autonomous energy supply for information technology and telecommunications (e.g. by locally generated solar power or fuel cells).

> Initially, however, advances in digital technology have increased dependence on the power supply: whereas an analogue telephone could still be used via the analogue subscriber's fixed-line telephone network terminal even if the domestic power supply had failed, the same only applies to a limited degree to digital ISDN connections and end terminals. The increasingly popular tele-

32 On the other hand, the various competing companies offer similar services, meaning that where applicable, users can select the supplier whom he knows is particularly well prepared for power blackouts because of the contingency measures adopted. However, this would require suppliers to publicise their contingency measures; this has not been the case to date.

phone connections via VoIP modems or DSL routers only work if the power supply is functioning (Chapter III.2.1.4.2).

- The increase in interconnection points – a new level in the network hierarchy between feeder distribution interface and house connection – as part of the expansion of the DSL network is also problematic because these points rely on a power supply. If a power blackout strikes and these points don't have an emergency power supply, the customers who were connected to them would immediately lose their telephone and Internet connection.[33] This does not affect the continuing dependence of the local switching exchange on a power supply/emergency power supply.
- Developing telecommunications systems into the Next Generation Network (NGN) is also considered critical. This technology places greater emphasis on »switching-oriented intelligence in end devices at the margins of the network«, which rely on a power supply. Subscriber terminals that rely on glass fibre technology also require an external power feed (Fickert/Malleck 2008, p. 276).

CONSEQUENCES 2.1.4

As far as could be ascertained, there are no current, systematic and scientifically-backed data surveys on the possible consequences of a power blackout for the »information technology and telecommunications« sector. The available budget meant it was only possible to conduct limited original research and surveys among information technology service providers, telecommunications suppliers and other relevant experts. Based on the expert reports produced for the TAB and on other sources, the following section collates, systematises and analyses the available knowledge.

The sources used also include individual case studies of past power blackouts. Such analyses exist for the widespread power blackout on the east coast of North America that lasted for several days in 2003[34]; these are considered at the start of this chapter (Chapter III.2.1.4.1) before moving on to an outline of the possible consequences of an extensive power blackout for the sub-sectors within the »IT/TC« sector.

33 According to Fickert/Malleck (2008, p. 276) some of these interconnection points are supplied via the public electricity network and would stop working accordingly in the event of a power blackout. With other interconnecting points, pairs of copper wires that are no longer required for power supply purposes are used by the nearest feeder distribution interface and can thus benefit from its emergency power supply. However, it is not known how widespread this type of power supply is.

34 No corresponding analyses for Germany are known. However, the collection of personal reports by the public on their experiences during the »snow chaos in the Münsterland« does, however, provide some insight (even if somewhat unsystematic) into the use or non-use of telephones, the Internet and mass media (Cantauw/Loy, 2009).

Since the sector is almost entirely reliant on a power supply, the presentation of the consequences differs from that used for other sectors: Information processing and telecommunications continue to function for as long as the power supply is guaranteed, even if only to a limited degree (as in the case of an emergency power supply). However, once the (emergency) power supply can no longer be maintained, there is a total breakdown in information technology and telecommunications. With this sector, it is therefore not possible to present the consequences of a power blackout on the basis of differentiated time gradients, as used in the other sector-based analyses.

POWER BLACKOUT IN NORTH AMERICA (2003) 2.1.4.1

The largest power blackout in the history of North America began on 14 August 2003 and affected large parts of the states of Ontario (Canada), New York, Ohio, Pennsylvania, New Jersey, Vermont, Michigan, Connecticut and Massachusetts (USA) (Bialek 2010; Stefanini/Masera 2008). After one week, on 22 August 2003, the state of emergency was lifted in Ontario, and the power supply was fully restored in the affected regions from 23 August 2003 (Public Safety Canada 2006, p. 14). Overall, 62 GW of electrical power (Yamashita et al. 2008, p. 856) and 50 million people were affected. It is estimated that Ontario's economy suffered losses of 1 to 2 billion Canadian dollars. In the first 4 days, retail trade suffered a 40 % decline in sales, while petrol station sales rose by 30 % (Public Safety Canada 2006, p. 4).

The following discussion is mainly based on the situation in Ontario, Canada. It can be assumed that following a previous major power blackout in 1998 (ice storm), the level of preparations in terms of emergency power generator equipment and emergency planning was extremely good (Public Safety Canada 2006, p. 22 f.).

The activation of emergency programmes for the fixed-line telephone network meant operations could be largely maintained. However, problems were encountered with the replenishment of fuel for the emergency generators of the general distribution stations and also with the emergency calls system (911). People were asked to use the phone (fixed-line and mobile) only in emergencies (Public Safety Canada 2006, p. 21 f.).

Mobile telephone systems were heavily overloaded.[35] With regard to energy supplies for base stations with battery back-up, some mobile phone companies were able to use additional mobile generators that were procured at short notice from outside Ontario to re-charge their batteries. By the fourth day after the power crisis started, all mobile phone services were functioning normally again

35 This experience led to the Canadian Government initiating the launch of »Wireless Priority Services« (WPS) in 2004.

(Public Safety Canada 2006, p. 22). However, Townsend/Moss (2005, p. 10) assume that mobile phone services in the north-east of the United States suffered serious disruption as the local antennae and switching stations were only equipped with standby batteries with a maximum capacity of 4 to 6 hours.

Connections to the worldwide Internet were badly affected, however. According to analyses by Renesys Corporation (Cowie et al. 2004), although the major transmission routes (»backbones«) were hardly affected by the power blackout, 3,175 of 9,700 networks identified in the affected areas experienced connectivity failures. With 2,000 of these networks these failures lasted for more than 4 hours; with 1,400 they lasted for more than 12 hours and some even suffered connectivity failures lasting more than 2 days. According to Cowie et al. (2004, p. 1 f.), the Internet was simply not yet able to match the reliability of the telephone system. Companies' large data centres were generally able to continue operations (Public Safety Canada 2006, p. 23 f.).

Press companies endeavoured to provide the public with information and were in most cases able to continue operating their technology with the aid of emergency generators. For example, on the first day after the crisis set in, the Toronto Star was able to produce a 16-page emergency edition, while the Ottawa Citizen was able to continue normal production as it had just purchased new emergency power generators.[36] The headquarters of Associated Press (AP) 02 in New York were temporarily transferred to Washington and Dallas on account of the power blackout.

Although the major television channels were able to continue broadcasting their programmes, it was generally not possible to receive programmes in the affected areas. The most up-to-date and perhaps most important source of information (from the onset of the crisis in the afternoon of 14 August 2003 until the morning of 15 August 2003) was the radio, which was able to transmit on a continuous basis and could be received via battery-operated radios. Radio broadcasters, newspaper publishing houses and television companies generally implemented emergency plans and were able to draw on sufficient emergency generators.

FIXED-NETWORK TELEPHONY 2.1.4.2

The fixed-line telephone network that is primarily used for voice telephony, fax and also as an access network to the Internet – including via broadband – is heavily dependent on a mains-operated power-supply; this is especially true for the end terminals and for the first hierarchical echelon in the network, the local switching exchanges.

36 Deverell (2003) emphasised the important role of the printed media during the power blackout in Stockholm in 2001.

End terminals and subscriber terminals

Whereas analogue telephones, which are now hardly used, do not rely on an external power supply and are supplied with the required low levels of energy from the nearest local switching exchanges via the telephone cable,[37] the base stations for the now popular cordless telephones (based on the DECT standard) do depend on an external power supply. A cordless telephone that can still operate because it has a battery is of no use because no connection can be made to the base station.

Provided ISDN telephones can be run using an emergency power supply, they can be supplied with power in the same way as analogue telephones via the local switching exchange. However, this only applies to one ISDN end terminal per ISDN connection, whereas several end terminals are usually connected.

However, the trend within fixed-network telephony is generally moving towards the use of VoIP via DSL routers or cable modems. Although the proportion of analogue telephone connections in the total of 39 million fixed-network telephone connections is still around 50 %, it is losing huge ground to VoIP connections via DSL or upgraded broadcasting cable networks. The proportion of ISDN basic rate connections is also stagnating. 11 million DSL broadband accesses are processed via Telekom AG's total of 26 million analogue or ISDN telephone connections; these DSL broadband accesses are themselves primarily designed for VoIP telephone (Bundesnetzagentur 2009, p. 19 ff. – all figures refer to the status in mid-2009). The increasingly popular use of Internet telephony via services such as Skype has not been considered in these calculations.

According to the information available, DSL routers and cable modems do not have any battery back-up; they therefore all depend on an external power supply and would fail immediately in the event of a power blackout. Fixed-network telephony and Internet access would be immediately interrupted in such a case.

Access and connection networks

The telephone network as such is structured on the basis of hierarchically organised, computer-based switching exchanges. A rough distinction can be made between local switching exchanges and trunk exchanges. Both depend on a continuous power supply. End customers' access lines lead directly to a local switching exchange; according to current estimates, there are between 5,000 and 8,000 such exchanges, each typically supplying 10,000 to 100,000 customers. After the end consumers' end terminals, the local switching exchanges represent the second key bottleneck in terms of access to the fixed network during a power

37 In the experience reports on the power blackout that occurred in Münster in 2005, repeated mention is made of the fact that analogue telephones were brought back into use.

blackout. Although they have uninterruptible power supply systems, these are designed to ensure continuous continued operation in the event of a short-term power blackout. The energy they store can be exhausted after just 15 minutes; it may, however, last for 8 hours depending on the location and operator (Reinermann 2009, slide 15). Once this point is reached, all customers connected to the fixed network are no longer able to access it.

An even greater number of customers would be affected in the event of a failure in trunk exchanges. These are therefore better protected with emergency power generators and could maintain operations for between 8 and 48 hours (Reinermann 2009, slide 15) or even for 3 to 4 days (Hiete et al. 2010, F 29) without an external power supply. If a widespread power blackout occurs, however, the improved emergency power supply of the trunk exchanges is essentially irrelevant because all local switching exchanges fail in the affected area and the trunk exchanges do not actually come into play. The improved contingency provisions for trunk exchanges are only effective in the (more frequent) scenario of a small-scale power blackout (e.g. one affecting an area of a city). If the trunk exchange is in the area affected by the power blackout but the local switching exchange is outside this area, telephone communications can be maintained for a few days through the use of emergency power generators.

The emergency power capacities in the fixed-network exchanges can differ according to whether a region is mainly rural or urban. These capacities may only last for 2 hours in rural areas, for up to 6 hours in small towns and for up to 48 hours in major cities (Unger 2009, slide 16), and according to Hiete et al. (2010, F 29) even for several days. Here, too, switching centres with more users are better protected than those with fewer users.

All telephone customers residing in the area of the power blackout who do not have an analogue telephone or ISDN telephone capable of operating on an emergency power supply immediately find themselves unable to make telephone calls. Customers with analogue phones or ISDN phones that are capable of operating on an emergency power supply can use these phones only until the uninterruptible power supply of the relevant local switching exchange fails, which will happen after a few minutes to a few hours.

It is clear that the obligation to provide »appropriate« technical contingency measures to safeguard against breakdowns »that cause considerable disruptions to telecommunications networks« as stipulated in Section 109 of the Telecommunications Act (TKG) has hardly any effect in the event of a widespread, prolonged power blackout. Currently, »appropriate« only appears to apply to precautions against a short-term power blackout affecting a small area. The fixed network's low level of reliability in the event of a power blackout also became apparent during the »snow chaos« in Münster in 2005. 88 % of the 592 residents questioned (in a study on the consequences for the food sector) were unable to use the fixed network (Gardemann/Menski 2008, p. 46).

EMERGENCY CALLS, EMERGENCY TELEPHONES, PUBLIC TELEPHONE BOXES

The standardised European emergency number 112 can be dialled free of charge from any working telephone (fixed or mobile network). This also applies to mobile phones without any available call credit or a current contract. The emergency number can also always be dialled from telephone boxes without the need for coins or a pre-paid telephone card. Emergency calls are dealt with on a priority basis in the telephone switching system, meaning they are forwarded even if the telephone system is overloaded.

However, emergency calls only function if the end terminal can make a connection to the telephone network (via the nearest local switching exchange or mobile network base station). If a widespread power blackout occurs, this will only be possible for a few minutes or hours.

Some emergency telephones as found, for example, on motorways, in tunnels or at railway stations (although to a reducing degree due to the popularity of mobile phones) are powered by solar energy independently of the electricity grid. Their use would therefore be guaranteed.

Public telephone boxes are also generally reliant on an external power supply and a functioning local switching exchange. They therefore also represent a limited alternative in crisis scenarios.

MOBILE TELEPHONE SYSTEM 2.1.4.3

Mobile telephones only represent a limited substitute for the fixed-line network in the event of a power blackout. In contrast to the fixed network, all end devices are equipped with an internal power supply. However, it is likely that the base stations (roughly comparable to the local switching exchanges in the fixed-line network) would stop working relatively quickly, meaning customers in the catchment area of these base stations would be unable to obtain a connection. These base stations have an uninterruptible power supply and like the local switching exchanges in the fixed network, can fail after just 15 minutes; however, depending on the operator and local conditions, they may be able to bridge up to 8 hours.[38]

38 Estimates concerning the emergency power supply of transmission equipment and base stations vary considerably. Prognos (2009, p. 81) assumes that »a few« transmission facilities are equipped with a short-term emergency power supply. According to Hiete et al. (2010, F 29 f.), too, »many base stations are not protected against disruptions to the power supply; some have uninterruptible power supply (approx. 2 hours), others have

It is assumed that the central switching exchanges of the mobile telephone networks that have emergency power generators can maintain their operations for between 8 and 48 hours (Reinermann 2009, slide 16, see also Mansmann 2008). Hiete et al. (2010, F 29) even estimate that these mobile services switching centres (MSC) would only fail after around 4 days.

The logic of supplying mobile telephone transmission and switching centres with emergency power is the same as for the fixed network. The higher the switching centre is in the network hierarchy, the better its protection against a power blackout. This is designed to minimise a network failure in the event of power blackouts affecting small areas, but as already established in the case of the fixed network, offers little help in the event of a widespread and prolonged power blackout.

There is, however one difference: in contrast to a fixed-network connection, mobile phone users are mobile. They may find themselves at a location within the area affected by the crisis where a base station required for dial-up and an MSC (i.e. a »trunk exchange«) are equipped with an emergency power generator. If one assumes that such »hotspots« would be maintained in the major cities of the area affected by the crisis, then it would be possible to make calls between mobile phone users within these zones and with mobile phone users and fixed-line users outside the crisis area; use of the Internet may also be possible. However, the precise underlying technical conditions of such a scenario would have to be examined on an individual basis. Telephone calls would also be possible if users moved close enough to the »edges« of the area affected by the power blackout so that they fell within the transmission range of facilities outside this area.

In addition to the precarious nature of the power supply, another risk factor is that in a disaster scenario, the difficulties within the fixed-line network and the increased need for communication mean mobile phone networks become over-

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stationary emergency power generators that can supply emergency power for several hours«. Furthermore, Hiete et al. (2010, F 29) assume that today, provision is no longer made for uninterruptible power supply or emergency generators when building new transmission facilities. By contrast, the Vodafone mobile network is, according to Mansmann (2008, p. 89), fully supplied with emergency power. Stand-by diesel ensures central network components can bridge a long power blackout. However, small individual base stations that ensure additional capacities in major cities could fail immediately. With the telecommunications companies O2 und E-Plus, the base stations have battery back-up and can thus continue to operate for around an additional 2 hours. O2 is equipping new base stations with fuel cells. The next highest level of the base station controller (BSC) is designed to operate independently of the grid for 4 to 6 hours; the central switching exchanges (including to other networks via MSC) have emergency diesel for several days. If the power blackout threatens a base station that is of strategic importance, this would be supplied with power using mobile generators.

loaded and many telephone calls cannot be connected. Text and other mobile data services are affected in the same way.[39]

Emergency calls must, however, be given priority treatment during a crisis scenario. Moreover, Section 3 [3] of the Law Concerning the Transformation of the Deutsche Bundespost Enterprises into the Legal Structure of Stock Corporation (PTSG) provides for privileged access for certain (authority-based) operators. This aims to ensure that in a situation where the mobile phone network is operating but is overloaded with a higher than average call volume, certain preferential users will still be able to make calls.

SATELLITE COMMUNICATION

Satellite telephones (e.g. that use the Inmarsat system) that are today also offered as mobile hand-held devices and offer several days' stand-by operation and several hours of call time, represent a possible substitute for voice and data services in the disaster scenario that forms the basis for this report. They enable communication between satellite telephones and also with fixed-line and mobile phone users who are still able to be contacted.

However, the connection is also provided via a base ground station that requires a power supply. If the German ground station can no longer be supplied with power, its functions could be taken over by a different ground station in another country. There is a certain technical restriction in that the telephone must have free »vision« to the satellite. This is not, for example, always the case in narrow valleys situated high in the mountains (Jost 2005, p. 29). Due to the high costs of purchasing and operating a satellite telephone, this means of communication does not represent an alternative option for widescale use in a crisis scenario.

INTERNET 2.1.4.4

With the Internet, it is important to differentiate between end devices that rely on a power supply (desktop computers, servers) and those that have their own internal power supply (laptops, web computers, smartphones, etc.). Whereas the first category stops working immediately (private households and small companies are unlikely to have an emergency power supply; medium and large companies are more likely to have one), battery-operated devices can still be used for between a few hours and a few days depending on their charge status and the way in which they are used. However, whether such devices permit access to the

39 The aforementioned study on the power blackout in the Münsterland reveals that in that area, mobile telephones proved very unreliable, even during a power blackout that »only« lasted a few days rather than for a longer period. 73 % of those surveyed were no longer able to »use their mobile phones« (Gardemann/Menski 2008, p. 46).

Internet depends on the type of access and on the situation in terms of the access and remote transmission network.

Here, the same essentially applies for the Internet as has already been said with regard to the fixed-line network, the broadcasting cable network and the mobile phone network, all of which represent possible networks for accessing the Internet: all DSL and cable modem means of access to the Internet are generally lost with immediate effect because they do not have battery back-up. Modems or mobile phone access devices (for the Internet) that are integrated into laptops can function for as long as they are supplied with power by the laptop battery. The same applies to smartphones and similar battery-operated mobile devices that offer Internet access.

However, here too, there is still the question of whether the modem reaches a working local switching exchange/DSL switching centre (DSLAM) or base station in the mobile network. These generally have an uninterruptible power supply that stops working after minutes or a few hours. Consequently, the Internet can no longer be accessed even if central remote transmission networks (backbone networks) are still able to function because of a good emergency power supply.

DATA CENTRES 2.1.4.5

Data centres of large companies, service data centres or Internet server farms, web hosters, etc. are considered to be well prepared for power blackouts. It can thus be assumed that the data lines between these data centres at their terminal points and amplifiers are similarly well protected. Operators of large data centres generally also have different locations meaning that where necessary, the operations of a data centre that is at risk can be transferred to another centre along with its business-critical processes. In all cases, the emergency power supply is designed to end on-going processes in a controlled way, to secure data and to establish emergency operations. This does not mean that all contingency measures will be implemented in a serious scenario.

EMERGENCY SERVICES COMMUNICATIONS AND EMERGENCY SERVICES NETWORKS 2.1.4.6

In Germany, the BOS radio communications system is set to change from its legacy analogue system to a new digital system based on the TETRA standard. TETRA is soon to be introduced on a nationwide basis for 500,000 users within, for example, the police, the fire service, the emergency medical services, the THW and the customs authorities. Overall, around 4,300 antenna locations and 62 switching centres need to be installed (Hiete et al. 2010, F 28).

In terms of dependence on the power supply, the switch to TETRA would appear to represent a step backwards. Whereas the old analogue BOS radio relay stations had an uninterruptible power supply that could last for 4 to 8 hours, the base stations of the new TETRA system are only designed to allow battery-based bridging of 2 hours (Hiete et al. 2010, F 30). The emergency services radio network appears to be ill-prepared for a widespread and prolonged power blackout. Although mobile, network-independent radio stations could be used, it is not known how many such alternative stations the TETRA operators have.

»Normal« government communications and communication by the federal administration is via specially secured networks including in particular the IVBB, the IVBV and the Federal Administration Network (BVN). These are to be consolidated into a joint, more efficient and more secure network infrastructure known as the »Federal Networks« (NdB) under the aegis of the BMI. As with the BOS radio network, this is a private data and telecommunications network that is specially protected against external attack. The key networks and network resources of IVBB and IVBV are equipped with emergency power generators that generally offer a capacity of 2 to 3 days. A bridging capacity of 72 hours is planned for the NdB network infrastructure. However, it should be noted that it will also depend on the emergency power supplies of the individual authorities in the network as to whether they can use the NdB. It is assumed that most of the larger authorities and institutions in Berlin and Bonn will have emergency power generators with a similar capacity to the network infrastructure.

RADIO BROADCASTING 2.1.4.7

Most end devices and especially television receivers in private households depend on an external power supply. Since private households are unlikely to have an emergency power supply, it generally becomes impossible to receive television immediately a power blackout strikes.

There are a far higher number and variety of radio devices, ranging from car radios to radio alarm clocks and mobile telephones with radio reception. Many of these devices have batteries that permit radio reception in the first and often particularly critical hours after the onset of a crisis. This also corresponds to the experiences during the power blackout in Canada in 2003, when the radio proved to be the most important source of information during the first 12 hours (Chapter III.4.1; Public Safety Canada 2006, p. 23).[40]

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40 The somewhat anecdotal reports by residents of the Münsterland on the power blackout in 2005 confirm the importance of radio (Cantauw/Loy 2009), whereas Prognos (2009, p. 38) assumes (albeit without quoting further sources) that people now have very few network-independent radios. In an empirical study on the consequences of the power blackout in the Münsterland in the autumn of 2005 for the food sector, questions were included on the use of means of communication; however, the specific use of radio devices was not examined (Gardemann/Menski 2008, p. 46 and p. 2 of the questionnaire in the appendix).

Public-law radio stations must fulfil a statutory supply requirement as regards emergency communication and information. Consequently, radio stations have emergency studios allowing them to continue reduced production operations for several days. The same safeguards are in place for (terrestrial) transmission technology (Prognos 2009, p. 82). Since editorial research capabilities depend on means of communication such as telephones and the Internet, such capabilities may be restricted if, for example, reporters at local level want to send information to the transmitting studios or if the editorial team wants to communicate with individuals at local level (officers, emergency forces, citizens).

THE PRESS 2.1.4.8

Press and printing companies are major consumers of energy. Newspaper rotary printing presses alone require electricity volumes equivalent to those used by a few hundred to a thousand households. Since the print process between copy deadline and sale spans a window of only a few hours and is extremely time-critical, newspaper printing shops generally have emergency power generators that at least enable emergency operations to be maintained. It can be assumed that similar precautions are taken for editorial systems, which exhibit many similarities with large data centres. This is confirmed by experience from the major Canadian power blackout in 2003 (Chapter III.4.1).

The extent to which newspaper publishing houses and major printing works could maintain emergency operations for several days and weeks depends on the extent to which replenishments of diesel for the emergency power generators can be ensured.

CONCLUSION 2.1.5

The consequences of a widespread, prolonged power blackout for information technology and telecommunications must be considered dramatic. In particular, telecommunications and data services would fail after a few days; in some cases, this would happen after just a few hours or even immediately.

VOICE AND DATA COMMUNICATIONS INFRASTRUCTURE

Where all components are closely interlinked and totally reliant on electricity, this will lead to a rapid failure (i.e. immediately or at most after minutes or hours), especially for the public voice and data services used by the public. It is therefore clear that contingency measures for a power blackout are geared towards short-term, small-scale blackouts, not ones extending over several regions and lasting for several days and weeks.

The complex topology of information and communications networks with their many end terminals, switching centres, network components and network hierarchies results in varying levels of dependence on an external power supply (Table 3). With a fixed network telephone system the (digital) end device and subscriber terminal are the first to stop working, followed by the first switching hierarchy of the local switching exchanges. With mobile networks, the end devices that can function for a few days if charged and used under moderate conditions would be less affected compared with the base stations that allow users to dial into the networks. The variety of devices, networks, configurations and architectures makes it difficult to make a precise estimate as to the exact point when a respective component is likely to fail. Ultimately, however, this is not important because in any communications network, the weakest component or first component to fail will cause the service as a whole to stop functioning.

TABLE 3 FAILURES IN THE »INFORMATION TECHNOLOGY AND TELECOMMUNICATIONS« SECTOR, CATEGORISED BY TIME FRAME

	Terminals	Switching technology	Backbone networks
Fixed-line network (with analogue terminal)	**	**	****
Fixed-line network (DSL connection, VoIP)	*	**	****
Mobile phone	***	**	****
Satellite radio	***	****	****
BOS	***	**	**
Internet	*	**	****
Emergency services networks (BOS)	***	***	***
Television	*	***	***
Radio (battery-operated radio, car radio)	****	****	****

* immediately; ** within hours; *** within days; **** within weeks

Note for readers: With regard to onset of failure at the respective level, it should be noted that the weakest component determines the duration. This is highlighted.

Own image

The findings regarding voice and data communications for private households do not apply in the same way to companies and authorities. Here, the current status of available information only makes it possible to conclude that it is necessary to consider the emergency power supply for information technology and telecommunications in commercial and public sectors on a case-by-case basis. It is not possible to make a blanket statement, applicable to all devices and networks, on which areas are well prepared for a power blackout and which are less prepared or not prepared at all.

Private, specialised and non-public data networks must be distinguished from public networks. Examples include the payment transaction networks of the banks which are well protected against power blackouts (Chapter III.2.6) or the German Research Network (DFN), which is guaranteed to continue functioning for a few hours or minutes and therefore offers the same level of safeguarding as its »customers«, i.e. university research centres and scientific institutes. With this type of private network, the customers (i.e. the Association of Banks or the German Research Network) can stipulate the required level of emergency power supply to the service providers (Telekom or other telecommunications suppliers). The federal communications networks such as the IVBB or the IVBV are also private. These networks can generally be operated for at least 48 hours with the aid of emergency power generators.

By contrast, the antenna locations of the new digital BOS network for the police, emergency medical services, fire services and the THW can only continue to function for 2 hours using a network-independent power supply. Essentially, two (electronic) means of communication – i.e. amateur radio and satellite radio – remain whose low levels of power consumption and ability to divert to transmission locations outside the affected area mean they can continue to function even during a widespread and prolonged power blackout. It is clear that these two radio technologies can only replace customary communications flows to a minimal degree.

MASS MEDIA

The sector of printed (newspapers) and electronic mass media (television, radio) must be considered separately from voice and data communications and is especially important for communicating with the public in times of crisis. Public-law broadcasting stations are extremely well prepared for a power failure. The same cannot be said for the receiving devices in households. Although broadcasting stations are able to transmit, citizens are unable to receive television programmes without electricity. Consequently, radio – which can be received via the millions of battery-operated devices owned by the public – becomes one of the most important channels for informing the public in the event of a crisis. Newspaper publishers and printing shops may offer a certain level of operating capability with the aid of an emergency power supply and be able to contribute towards keeping the public informed. However, estimates of these capabilities vary and require further research.

TRANSPORT AND TRAFFIC 2.2

The analysis of the »transport« sector is based on the four key modes of transport: road, rail, air, water.

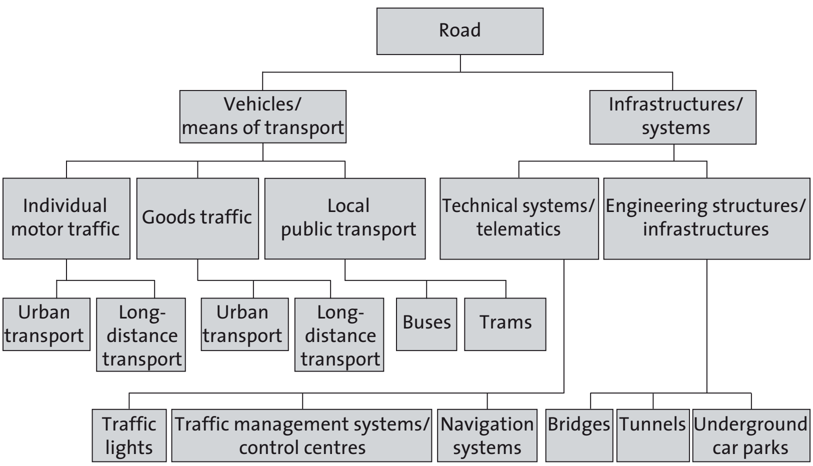
All sub-sectors are heavily dependent on the power supply. This applies to both the means of transport and also the infrastructures, as well as to the management and organisation of the respective transport modes. One of the main reasons for the recent increased dependence on the power supply is the sharp rise in the use of modern information and communications technologies, especially in vehicles and for traffic management purposes, not forgetting the operation of various building structures such as underground car parks, tunnels or bridges.

STRUCTURE 2.2.1

ROAD

Germany's road network has a total length of around 231,000 km. This includes the federal motorways (approximately 12,600 km), the federal highways (approximately 40,700 km), the country highways (approximately 86,600 km) and the district roads (approximately 91,500 km). There are more than 330 road tunnels with a total length of over 250 km.

FIGURE 10 STRUCTURES OF THE TRANSPORT MODE »ROAD«



Source: EBP 2010, p. 89

Roads handle all individual motor traffic and a large proportion of goods traffic and local public transport. Every day in Germany, more than 28 million people use buses and trains and cover more than 90 billion person-kilometres (VDV website). The segments of local public transport that use rail networks rather than roads (e.g. trains of DB AG, underground trains) are discussed in Chapter III.2.2.3.2.

The »roads« sub-sector (Figure 10) fulfils a number of functions in fields such as leisure, business transport, commuter transport, the supply of goods and emergency/rescue services.

RAIL

In Germany, the rail network of Deutsche Bahn AG (DB AG) has a length of around 38,000 km and moves passenger trains[41] and around 5,400 goods trains of DB Schenker Rail (the logistics company of DB AG) on a daily basis. In addition, around 300 additional (private) railway companies that do not belong to DB use its railway network. These companies have their own electric and diesel-powered trains. The Connex Group is one of the largest private railway companies for passenger transport. A key player in the field of goods transport is Rail4Chem Eisenbahnverkehrsgesellschaft. The DB network also includes other infrastructures (Table 4).

TABLE 4 INFRASTRUCTURES OF THE DB NETWORK

Infrastructure	Number
Passenger railway stations	5,718
Tunnel structures	770
Bridges	27,107
Railway control centres*	4,479
Points/junctions	69,311
Level crossings	18,051
Filling stations (for diesel locomotives and buses)	188

* A railway control centre is a railway facility from which equipment in and on the track system (e.g. points and signals) can be set on a central basis for train journeys and for shunting purposes.

Source: EBP 2010, p. 105

41 According to its own figures, Deutsche Bahn AG carries around 5 million passengers per day (BBK 2008 a, p. 121).

In the field of passenger transport, DB AG has a total of 415 diesel locomotives and 3,969 diesel railcars available for regional and city transport, while the Connex Group has around 118 diesel locomotives. Overall, therefore, these two large companies alone have at least 4,500 diesel locomotives/railcars available that could be used in the event of a power blackout. In the goods transport sector, DB's subsidiary Rail Deutschland uses over 1,143 diesel locomotives. Traction current for rail transport is supplied by 55 power stations and converter stations. These are used to feed the railway system's own 110 kV network. DB does not operate many power stations of its own and purchases most of its traction current from third parties.

Points, signal equipment, safety systems and maintenance plants along with retail and trade in and around train stations and also administrative buildings are not supplied with electricity from the traction current network; they are supplied on a decentralised basis via around 100 different 50 Hz lighting mains and power mains. The 50 Hz lighting/power current is mainly taken from the local public network; only a small proportion is produced by DB AG itself. If the public grid fails, the above systems and infrastructures are affected immediately.

Centralised control of the 110 kV/16.7 Hz high-voltage network could prove a weakness. This is where energy-use planning and network operations management for DB Energie's high-voltage network takes place and fluctuations in demand of up to 300 MW are balanced out within a few seconds. Disruptions to the centre could thus affect the planning and coordination of power distribution and thus affect optimum operation of the traction current network (BBK 2005a).

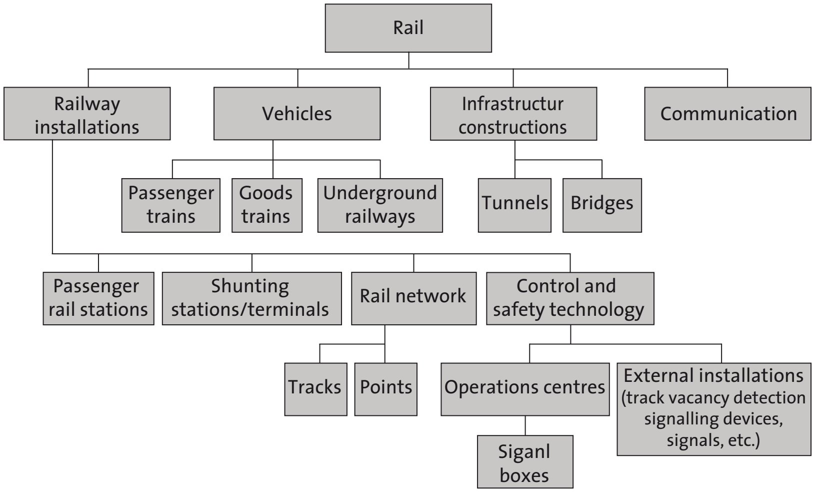
DB Energie has over 188 filling stations in Germany to enable the operation of diesel rail vehicles and in some cases also buses and lorries.

In contrast to above-ground railways, underground railways are generally rail transport systems that are designed as separate systems that have no junctions and that are independent of other urban transport systems.[42] They form closed systems that are immediately affected by a power blackout. Germany's underground rail system transports several million people each day.

The »rail« sub-sector (Figure 11) fulfils primary functions in the fields of commuter transport, business transport, leisure and supplies.

42 Many German cities and conurbations have systems similar to underground railways whose routes also in some cases run on independent railway structures outside of the tunnel system.

FIGURE 11 STRUCTURES OF THE TRANSPORT MODE »RAIL«



Source: EBP 2010, p. 108

AIR

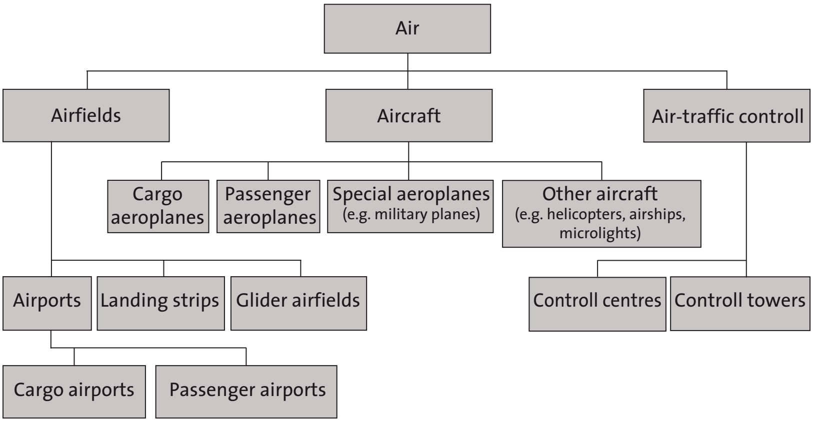
The »air« sub-sector can be sub-divided into airfields[43], aircraft and air-traffic control (Figure 12)

The functions of the sub-sector »air« primarily involve the fields of tourism/business traffic[44] and supplies.

43 Airfield is the generic term for all land designed for enabling safe aircraft take-offs and landings. According to the Aviation Act (LuftVG), a distinction is made within airfields between an airport, a landing strip and a glider airfield (EBP 2010, p. 121).

44 Frankfurt Airport has an annual passenger volume of around 56 million passengers.

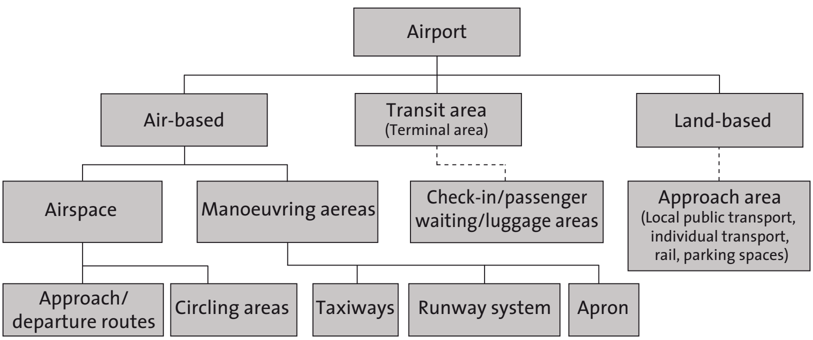
FIGURE 12 STRUCTURES OF THE TRANSPORT MODE »AIR TRAFFIC«



Source: EBP 2010, p. 123

Germany currently has 38 airports, including 32 international passenger airports. The airports are run as private enterprises, although the public authorities (Federation, Länder and parishes) do have a financial stake in some cases. Figure 13 below shows the structures of an airport.

FIGURE 13 STRUCTURES OF AN AIRPORT



Source: EBP 2010, p. 124

EMERGENCY POWER SUPPLY AT FRANKFURT AM MAIN AIRPORT

At airports, air traffic control facilities and the navigation lighting for the runways are especially important. Runway lighting is guaranteed via short-break emergency generators, thus ensuring maximum availability. UPS systems protect air-traffic control facilities, with special batteries storing power for an emergency.

Around 50 emergency diesel units with special starter batteries are distributed across the area of Frankfurt Airport. They safeguard the supply of electricity to consumers in the various applications and facilities. Overall, these emergency power generators provide electrical power of 53 MW. Separate 24 V control batteries safeguard system control, monitoring and reporting, while 400 V UPS batteries guarantee the supply of power to computer systems.

Additional batteries store the necessary reserve energy for the central control room and its computer systems. In addition to the internal power supply, the airport's air conditioning equipment is also monitored and controlled from here.

Source: www.batterieportal.com; amended

The non-military airports in Germany must meet the requirements of the International Civil Aviation Organisation (ICAO) on emergency power supply (EBP 2010, p. 121). To be able to ensure ground operations[45], the major airports have efficient standby power supply systems and fuel stores. Depending on their size and the amount of energy required, airports are thus able to at least maintain ground operations for some weeks (EBP 2010, p. 122).

However, this maintenance of ground operations at airports does not permit regular air traffic during the power blackout.

WATER

The federal waterways network encompasses 7,350 km of inland waterways, of which around 75 % are rivers and 25 % canals. There are also around 23,000 km^2 of sea lanes. Facilities on the federal waterways include 450 sluice chambers and 290 weirs, 4 ship lifts, 15 canal aqueducts and 2 surface dams. The main network of around 5,100 km includes the main waterways of the Rhine (and its tributaries), the Danube, the Weser and the Elbe and the connecting canal systems to the Oder and to the Danube (BMVBS 2010). The German federal waterways are a key element of the »wet« Trans-European Network (TEN).

45 In this context, ground operations include ensuring the ability to carry out take-offs and landings and also ensuring passenger and baggage handling.

Each year, goods quantities of up to 240 million tonnes are transported over a distance of 65 billion tonne kilometres. This represents around 75 % of railway goods transport and around 14 million lorry journeys. Around 1.5 million containers (TEU)[46] are transported on inland waterways. Approximately 400,000 jobs depend on inland water transportation and ports. The »White Fleets«[47] and river cruise ships are assuming increasing economic importance (BMVBS 2010).

Germany has over 100 modern, public sea and inland ports. 56 of 74 city regions in Germany have a connection to an inland waterway (BMVBS 2010). The most important German sea ports are Hamburg, Bremen/Bremerhaven, Wilhelmshaven, Lübeck and Rostock, while the most important German inland ports are Duisburg, Cologne, Hamburg, Mannheim, and Ludwigshafen. The port at Duisburg is the largest inland port in Europe (EBP 2010, p. 135).

In 2007, around 312 million tonnes of goods were transhipped in Germany's North Sea and Baltic Sea ports. Of this volume, around one-third was accounted for by container transport (15.2 million TEU[48]). In terms of passenger sea transport, around 30 million ferry guests arrive at/depart from German sea ports each year.

THE PORT OF HAMBURG

The Port of Hamburg is the largest sea port in Germany and the third largest in Europe (after Rotterdam and Antwerp).

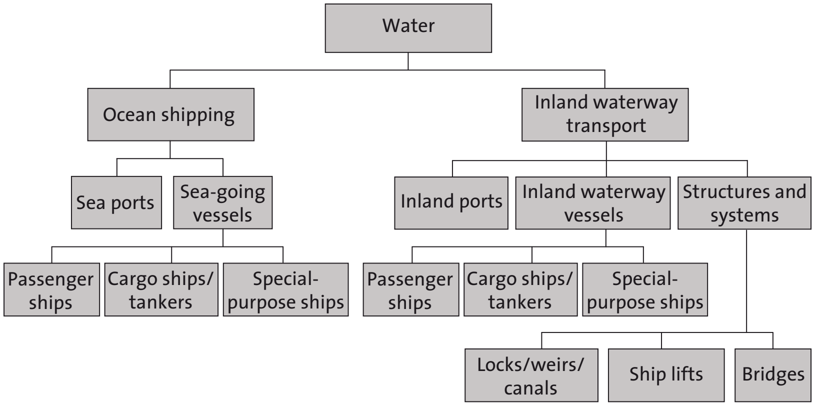
It offers 320 berths for seagoing vessels on 35 km of quay walls, including 38 large-ship berths for container carriers and bulk carriers, 97 berths on pile moorings and 60 landing wharves including ferry wharves of the company HADAG Seetouristik and Fährdienst AG.

In terms of land area, the port has 137 km of public roads, 156 km of embankments and 314 km of port rail tracks. There are three road and pedestrian tunnels and 147 bridges, including 53 fixed railway bridges, 52 fixed road bridges, 5 pedestrian bridges, 9 other bridges and 11 moveable bridges.

The transport mode »water« (Figure 14) fulfils primary supply functions. It is of less importance for leisure and business transport (e.g. ferries or cruise ships) (EBP 2010, p. 136).

46 TEU = Twenty Foot Equivalent Unit; a container 20 feet long
47 »White Fleet« refers to the passenger ships of several German passenger ship companies (on inland and coastal waters).
48 Of this figure, around 10 million TEU are transshipped at the Port of Hamburg.

FIGURE 14 STRUCTURES OF THE TRANSPORT MODE »WATER«



Source: EBP 2010, p. 137

LEGAL BASES 2.2.2

In a disaster scenario, means of transport play a key role in managing the associated consequences and damage. The Traffic Services Act (VerkLG) is therefore of paramount importance.

The Act aims to ensure sufficient transport services[49] in the event of, for example, a natural disaster or particularly grave accident; this is, among other things, ensured through administrative assistance by the Federal Government. This includes transporting people and goods, making means of transport and transport systems available, and also use of the traffic infrastructure including communications and information systems. Bodies that can be obliged to provide services include transport companies and transport infrastructure companies (excluding mountain railways), shipping companies that sail under the German flag, and other owners of means of transport or transport infrastructures where these form part of a company's operations. Traffic services may only be requisitioned under the Act for a certain time and for a maximum of three months. Federal authorities who are authorised to issue requests include the BBK, the Federal Office for Agriculture and Food (BLE) and the THW. However, the Traffic Services Act can only be applied following a decision by the Federal Government.

49 Under the provisions of the Traffic Services Act (VerkLG), Deutsche Bahn AG has, for example, been assigned duties in the event of a crisis or state of defence; these duties are implemented by the company's civil emergency response department (BBK 2008a, p. 123).

ROAD

With the exception of the law relating to ensuring the provision of services, there are hardly any statutory rules governing the safeguarding of critical infrastructures in the field of road transport. The law relating to the conveyance of persons is the only area to reveal associated provisions – as for example in the Law on the Conveyance of Persons (PBefG) where »security and efficiency of operation« and »technical suitability« are requirements for a licence (Section 13). Moreover, companies must conduct their operations in accordance with the »state of the art« (Section 21 [1]). It can be assumed that this also includes measures in the event of a power blackout (EBP 2010, p. 85).

RAIL

According to Article 73 No. 6a of the Basic Law (GG), the Federation has exclusive legislative competence for railway transport and for railway infrastructures that are fully or partly owned by the Federation (railways of the Federation). Section 4 of the General Railway Act (AEG) specifies safety and security obligations concerning control and safety systems and also the supplying of traction current (BBK 2008a, p. 123). The duties of the Federal Administration of Railway Traffic (BEVVG) are performed by the Federal Ministry of Transport, Buildings and Urban Affairs (BMVBS) (Section 1 [1] of the Act on the Federal Administration of Railway Traffic (BEVVG)). The Federal Railway Authority was established to fulfil these duties. It is the safety authority for railways in Germany.

Railways that are headquartered in the Federal Republic but that are not owned by the Federation are supervised by the federal state in which they have their registered office. The respective Land government can assign railway supervision to the Federal Railway Authority either in full or in part (Section 21 [1] of the General Railway Act (AEG). Most federal states have made use of this option.

Finally, there are a number of safety/security-related standards which give the state opportunities to intervene in matters relating to supervisory functions (BSI 2005, p. 117).

AIR

According to Article 73 [6] of the Basic Law (GG), the Federation has exclusive legislative competence for air transport. According to Article 87d [1] of the Basic Law, air transport is administered by means of direct federal administration. According to Article 87d [2] of the Basic Law, duties pertaining to air transport administration may be assigned to the Länder under a federal law with the consent of the Bundesrat. The Länder then regulate administrative organisation themselves. However, they remain under federal supervision both in terms of the legality and also the expedience of implementation (BSI 2005, p. 108).

Airfields may only be established or operated with the approval of the Länder aviation authorities. Among other things, aspects relating to public safety and order must be considered (Section 6 [2] of the Air Transport Act). As the supreme air transport authority, the BMVBS ascertains if the licenses for airports serving general transportation purposes affect the Federation's public interests. The technical facilities and also operational processes are examined with regard to their compliance with national and international provisions. Every airfield must draw up an air security plan and submit this to the Federal Aviation Office (Section 16 [3] of the Aviation Security Act (LuftSiG). This must include measures to secure the airport. Corresponding precautions must be taken. Airport operators must immediately report any incidents that significantly impair operation of the airport to the licensing authority.

Within aviation, responsibility for emergency response lies with the air transport and aviation security authorities. They also deal with operational risks including a power blackout (EBP 2010, p. 86).

WATER

There are no statutory provisions explicitly relating to safeguarding of the shipping infrastructure (BSI 2005, p. 87). Within the federal Länder, however, special safeguards relating to the handling of hazardous goods are provided for at ordinance level.[50]. According to these provisions, corresponding precautions must also be taken to safeguard against a power blackout.

CONSEQUENCES 2.2.3

ROAD 2.2.3.1

0 TO 2 HOURS

Individual motor traffic

Serious disruptions occur immediately, especially in urban areas, as traffic lights, traffic management systems and road lighting stop working. There is a marked increase in traffic accidents – resulting in injuries and some fatalities. Increasingly congested roads (due to accidents and also due to the high volume of traffic) make it difficult for the police and emergency medical services to reach accident sites. In addition, the breakdowns in the telephone networks make it very diffi-

50 Example: Land Port Ordinance of Brandenburg sections 31 ff., Ordinance on Hazardous Goods in Ports of Mecklenburg-Vorpommern sections 13 f, General Port Ordinance of North Rhine-Westphalia sections 30 ff.

cult to alert the rescue services (Chapter III.2.1). Broken-down pumps mean vehicles can no longer be filled up at petrol stations (Beck/Vannier 2008).

Immediate problems are experienced in underground car parks: barriers block exits, ventilation, lighting and lifts stop working. With some modern buildings, however, underground car park components are connected to an uninterruptible power supply and to an emergency power system; no immediate problems are therefore encountered in such buildings. In car parks without an emergency power supply the barriers are opened after protestations from customers.

Initially, long-distance transport on motorways is hardly affected by the power blackout. Although traffic management systems stop working, this does not generally restrict the functioning of the motorways. Problems are, however, encountered with motorway tunnels. Some tunnels are closed because lighting and ventilation systems stop working.[51] The resultant diversions trigger initial traffic jams and bottlenecks in the subordinate road network. The power blackout also affects car drivers who need to fill up with fuel within the area affected by the power blackout and who leave the motorway to use motorway petrol stations. As the petrol station fuel pumps are not working, cars become stranded when they continue their journey. Some people decide not to continue their journeys and to wait until power is restored (EBP 2010, p. 90).

Local public transport

With local public transport, both electric buses that are in contact with an overhead power line and also trams come to an immediate standstill. Electric buses that are fitted with a diesel-operated auxiliary engine can continue driving and do not further impede the traffic flow. The drivers of vehicles that have come to a standstill contact their headquarters to find out the reason for the blackout. As soon as it becomes clear that no statements can be made regarding the duration of the blackout, the drivers open the doors and allow the passengers to alight. Depending on where the bus comes to a standstill, there may be an increased accident risk (EBP 2010, p. 90). Diesel-driven buses can continue their journeys. Their tanks permit operation for up to 24 hours. However, the increasing problems on the roads make it very difficult for these buses to keep to their timetables.

Major tensions develop at the headquarters of the local passenger transport operators. Depending on the means of communication that are still available, the

51 Small tunnels (less than 400m) are less critical in terms of ventilation and lighting. Here, there are no specific rules regarding power supply. According to the »Guidelines for Equipping and Operating Road Tunnels« (RABT), tunnels longer than 400m must be equipped with an uninterruptible power supply designed to last at least 15 minutes. The tunnels are blocked off if a power blackout strikes. For new tunnel constructions, this applies from a length of 80m (EBP 2010, p. 91).

relevant departments try to find out information on the duration of the power blackout.

Goods traffic

Goods traffic on roads in urban areas experiences similar problems to those encountered by individual motor traffic. Long-distance goods traffic is not initially directly affected by the power blackout. In the vast majority of cases, the larger tank volumes mean vehicles are able to travel through the affected region and fill up outside the area in question. Problems are encountered if tunnels are closed. With regard to deliveries in the area affected by the power blackout, problems are encountered with loading and unloading vehicles (e.g. loading ramps aren't working, gates won't close or open, scanners stop working).

2 TO 8 HOURS

Individual motor traffic

With individual motor traffic, the traffic problems in urban conurbations in particular only start to gradually ease towards the end of this time frame; the rate at which problems ease depends on the time of day. Drivers attempt to cope with the traffic lights and traffic management systems that have stopped working. Traffic accidents do, however, continue to occur, especially at critical spots. A large number of the people whose workplaces are affected by the power blackout cannot/can no longer work and return home. Increasing numbers of parents try to contact their children and arrange to collect them by car. The volume of traffic therefore remains high.

In some underground car parks without an emergency power supply, people who wish to exit a car park use force to dismantle or open the barriers that have not yet been opened by car-park staff (EBP 2010, p. 93).

Long-distance transport on motorways remains hardly affected by the power blackout. However, tunnels that have been closed remain blocked off.[52] The number of people at motorway service stations who can't continue their journeys because their fuel tanks are empty or nearly empty tends to increase. Mobile phone and fixed-line networks become less and less available during this phase. It is now virtually impossible for people to arrange to be picked up by relatives or friends (EBP 2010, p. 92).

Local public transport

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52 The provisions for tunnel closing systems (electronically controlled traffic signs, traffic lights and barriers) under the »Guidelines for Equipping and Operating Road Tunnels« (RABT) require an operating time of at least 60 minutes (FGSV 2006, p. 44).

Public transport continues to experience major problems. The urban transport operators try to tow away stranded buses and trams using traction-powered equipment. This is a complex task with trams because points can no longer be set by electrical means and have to be set manually. Diesel-powered buses can continue to operate. During this phase the transport operators will consider an emergency transport plan that includes restricting bus journeys to especially important routes.

Goods traffic

Goods traffic also has to contend with problems in cities. Increasing numbers of lorries are forced to return to their departure points because they are unable to deliver their goods. This applies if the delivery infrastructure at the destination (e.g. loading ramps, roller shutters, cold-storage rooms) is dependent on a power supply but does not have an emergency power supply and therefore stops working.

8 TO 24 HOURS

Individual motor traffic

Individual motor traffic in urban areas starts to reduce. More members of the public remain at home as workplaces are also affected by the blackout. People also try to cope with the consequences of the power blackout that are becoming increasingly evident within their own homes (e.g. freezers start to thaw, other kitchen equipment stops working, disruptions to the water supply). Accidents continue to occur because the public has not yet become accustomed to road traffic without traffic lights and lighting. Many roads and junctions remain blocked. Petrol stations remain closed. Most vehicle owners have taken their cars from underground car parks.

Apart from the tunnels that remain closed, long-distance traffic on motorways is still not really affected. However, the situation of the people who are »stranded« at motorway service stations and petrol stations (and who have not been collected by relatives and friends) becomes increasingly precarious because most communication connections are disrupted and service station operations can only be maintained to a limited degree (heating, sanitary facilities, food, etc.). Some people attempt to organise themselves or to purchase fuel.

Local public transport

The situation with local public transport remains unchanged. Stranded buses and trams continue to block traffic routes. Increasing attempts are made to tow these vehicles away. However, this becomes increasingly difficult because of the way the power blackout has affected the communications infrastructure. A few diesel-powered buses continue to operate. Emergency traffic plans have not yet been implemented (EBP 2010, p. 93).

Goods traffic

Goods traffic in urban areas continues to fall in the same way as individual motor traffic. As before, transit traffic by lorries with sufficient fuel in their tanks is not affected to any considerable degree.

24 HOURS TO 1 WEEK

Individual motor traffic

Individual motor traffic now reduces significantly. This is firstly due to the lack of fuel, because hardly any petrol stations in Germany have an emergency power supply. In addition, many workplaces and educational establishments and also static trade operations remain closed. The number of accidents thus falls significantly (EBP 2010, p. 94). More people switch to using bicycles. Increasing numbers of cycle trailers are used to transport loads. The emergency power supplies of modern underground car parks now stop working as well and the car parks are closed. Long-distance transport on motorways is still hardly affected by the power blackout. Individual road tunnels are opened again to facilitate the flow of traffic (EBP 2010, p. 95).

Local public transport

Stranded trams and buses are gradually recovered. It is still not possible to use electrically operated vehicles. The transport operators implement an emergency transport plan using diesel-powered buses.

Goods traffic

Goods traffic in urban areas also falls sharply. Increasing numbers of lorries with sufficiently large fuel tanks are used to bring deliveries of essential goods to the affected areas.[53]

A LOOK AT WEEK 2

There is little traffic on the roads. Underground car parks remain closed. Most people remain at home or – if homes can no longer be heated – some go to collective accommodation centres or meeting points set up in sports centres or community centres (Prognos 2009, p. 39 ff.). Trips that have to be made are done on foot or by bike. Other people move to regions that are not affected by the power blackout and stay with relatives and friends. Private long-distance traffic on motorways falls sharply. Motorways are still used for transit purposes,

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53 If a power blackout occurs in winter, it is necessary to determine supply axes that will be cleared of snow on a priority basis in the event of a snowfall.

but the risk of getting stranded on open stretches of roads deters many people from unaffected areas from undertaking journeys. If motorway tunnels remain closed, diversions are signposted and recommended diversions are broadcast over car radios. Selected key road tunnels are opened for traffic, even if ventilation and lighting are still not working.[54]

Public transport is restricted to a few diesel buses that mainly operate on inner-city routes. Public transport comes to a total standstill in places where it is not possible to ensure an emergency power supply through the use of diesel.

Goods traffic focuses on delivering essential goods to key points and is organised by the civil protection authorities and organisations.

CONCLUSION

With road traffic, the failure of traffic lights, lighting and traffic management systems and also the increased volume of traffic results in many accidents with injuries and fatalities in the first few hours. Roads become congested, numerous junctions are blocked. Delivery bottlenecks occur and problems are encountered in delivering all types of goods. In a few isolated cases people may react by panicking (e.g. in a traffic jam in a tunnel where the lights have gone out). Generally, however, it can be assumed that people will initially react in a calm way, not least because the power blackout is not expected to last long (EBP 2010, p. 103). After this, people start to actively attempt to deal with the situation. They switch to alternative means of transport, form transport cooperatives and arrange for goods and in some cases also fuel to be brought in from unaffected areas.

As the power blackout continues the use of means of transport is increasingly restricted. Most petrol stations cease working on a permanent basis. In the first week, individual motor traffic is mainly the result of people from outside the area travelling to the affected region and delivering essential supplies to relatives and friends or even collecting them. Petrol stations located at the edges of the affected area that still have a power supply are used more heavily. The loss of buses and trams and especially the restrictions faced by individual motor traffic mean increasing restrictions on basic mobility.

Underground car parks are closed after a few days. Tunnels whose safety (especially ventilation) cannot be guaranteed are initially closed. They are opened and made secure once it can be seen that the power blackout will last for some time and that the tunnels are required to keep key traffic and supply routes open.

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54 This is especially probable in tunnels where traffic running in different directions is separated; this is because the fact that traffic only travels in one direction means that a flow of air is created in each pipe of the tunnel and electric ventilation is not therefore absolutely necessary. Moreover, the risk of accidents in tunnels is reduced due to the decline in the volume of traffic (EBP 2010, p. 96).

Due to the somewhat chaotic situation during the first hours, some goods that are being transported by road experience delays in reaching their destination. When they do arrive, there are problems with loading and storage because infrastructures such as airlocks, loading ramps, roller shutters or cold storage rooms have stopped working.

As long as it remains unclear that a prolonged power blackout has set in, the companies responsible for road traffic such as urban transport operators will endeavour to resolve any problems arising on an independent basis. Lorries and towing vehicles are used during the first few days to tow away stranded trams and electric buses. Diesel buses can be used to implement a rudimentary emergency local public transport plan. These can only continue operating if supplies of the corresponding fuel can be ensured.

RAIL 2.2.3.2

0 TO 2 HOURS

Passenger and goods traffic on the rail network is disrupted immediately: trains come to a standstill on open routes, on bridges or in tunnels. Trains drawn by diesel locomotives or railcars can still travel to the next station, but many are blocked by an electrified train that has come to a stop. Because it is initially unclear how long the power blackout will last, managers don't initially order any evacuations. However, towards the end of the first 2 hours – and also because the mobile phone network is gradually breaking down – passengers in some trains become agitated, especially if the train has come to a standstill at an unfavourable location (e.g. in a tunnel, on a bridge or in an open field).

At train stations within the affected area, reduced operation is ensured firstly via uninterruptible power supply and later via emergency power systems. Most lighting and electric doors and gates still work. However, escalators, announcement boards, heaters, ticket offices and ticket machines and also computers in offices all stop working (EBP 2010, p. 109).

Diesel locomotives can still be used to perform work in shunt yards. However, railway control centres and points require electricity. Where systems allow, a decision is made to switch to manual settings. Communication is restricted. Light sources also fail. Container terminals where containers are loaded from rail to road are affected in a similar way to shunt yards because they are also dependent on the public electricity grid: cranes and ticketing systems[55] stop working, meaning containers can no longer be properly transhipped (EBP 2010, p. 109).

55 Means of recording the various goods on IT systems and tracking their transport.

Despite the power blackout, most operations control centres that are responsible for controlling railway traffic, railway control centres that are used to set points and external facilities such as signals or track vacancy detection systems are initially still able to function with the aid of an uninterruptible power supply and subsequently via emergency power systems. In the first few hours after the power blackout, train staff are still able to communicate with the control centre via the railway's mobile network (GSM-R). Initially, the track network and points are not affected by the power blackout. By contrast, fans and signals stop working in railway tunnels. Some tunnels are closed as a result.

Underground trains come to a standstill. Uninterruptible power supply and emergency power generators initially ensure ventilation and lighting in underground railway stations. Nevertheless, people do exhibit signs of unrest and start to panic in some cases. Passengers leave trains that have come to a standstill and are evacuated via the emergency lift shafts (EBP 2010, p. 110).

2 TO 8 HOURS

Most stranded trains have been evacuated. As there are a large number of trains in the affected area and police, emergency medical services and the THW are carrying out operations throughout the affected area, the numerous passengers who have left the trains can't be properly looked after.[56] Moreover, roads don't run alongside every train track. Some passengers are therefore forced to walk a long distance and/or rely on help from neighbouring communities. Contact with family and friends is severely restricted due to the increasing disruption to the mobile phone network (Chapter III.2.1).

Initially, there is no change in the situation regarding stranded goods trains. However, any perishable goods that are being transported may suffer, depending on the time of year. Hazardous goods that are being transported and that become stranded represent a particular risk (EBP 2010, p. 111).

The situation at railway stations starts to ease again towards the end of this period. DB AG is still unable to make any announcements on how long the power blackout will last. There are no signs of increased uncertainty. People waiting in the stations try to make contact with passengers in the stranded trains.

Initially, there is no change in the situation at shunt yards and terminals because it is not possible to predict how long the power blackout will last. DB AG starts to prepare available diesel locomotives to recover stranded trains.

56 Although DB AG has a number of buses, it is unclear whether these could actually be used due to the restricted communications capabilities (coordination) and to the traffic problems that arise.

Operating control centres, railway control centres and external facilities can still function with the aid of emergency power systems, but there is an increasing risk that they will stop working. During this period, the track network is only affected in winter time. In winter, parts of the network such as points may start to freeze if they can no longer be heated. There is no change in the situation on bridges and in tunnels.

Generally speaking, it is no longer possible to communicate with stranded trains using either the railway's mobile phone network or the public mobile phone network.[57]

8 TO 24 HOURS

Some of the stranded trains have been evacuated and the passengers concerned have received first aid or have been transported using buses. Diesel locomotives are able to tow away the first trains. However, problems are encountered when parking trains on sidings. Points work has to be carried out manually because electric points have stopped working. Yet the required coordination is severely restricted because of the disruptions to means of communication (EBP 2010, p. 112).

Passenger train stations are almost empty. People in the stations have been informed that the power blackout could last some time and are no longer waiting for passengers. Shops in train stations are closed. Many of the stations are also closed.

In shunt yards and terminals an attempt is made to recover stranded trains using diesel locomotives. Corresponding point setting operations are carried out manually. Most operations control centres, railway control centres and external facilities have stopped working. Some railway control centres can be operated manually.

The underground rail networks affected are still unable to function. Points of entry to the stations are closed.

24 HOURS TO 1 WEEK

Stranded passenger trains are gradually recovered with the aid of diesel locomotives. It becomes impossible to operate even a reduced timetable because of the breakdowns at operations control centres and railway control centres, and also because trains are still blocking some routes. However, an attempt is made to operate a restricted level of goods transport in order to supply the people in the

57 Requirements for batteries in the GSM-R devices installed in trains only call for an operating period of one hour (stand-by), whereby the device can actually be used for 15 minutes (EBP 2010, p. 111).

affected area with essential goods (EBP 2010, p. 112). Once the stranded goods trains have been recovered with the aid of diesel locomotives, trains are used to transport essential goods to the areas affected by the power blackout. In some cases diesel locomotives are used to transport goods on fixed routes, allowing points to be bolted down.

Operations in shunt yards and terminals are largely suspended. Some railway control centres can still be operated manually, but this only enables a very low volume of rail traffic to be handled. Operations control centres and external facilities are still not working (EBP 2010, p. 113). Locally, tunnels that were closed are re-opened once it becomes clear the power blackout is likely to last for a long time; this allows journeys to be continued with special precautionary measures. The few trains that do still operate in the region affected by the power blackout must manage without modern means of communication. Satellite telephones are unlikely to be used on a large scale.

Points of entry to the stations and underground railway stations remain closed. Operators use notices at the entrances to underground railway stations to inform the public that the stations will be closed for an indefinite period (EBP 2010, p. 113).

A LOOK AT WEEK 2

Working in consultation with the relevant Länder departments, DB AG specifies main supply axes that can be used to bring key goods by diesel locomotive from unaffected areas into the regions affected by the power blackout. The numerous restrictions (loss of operations control centres, railway control centres, safety signals, restricted passability of tunnels, bolted-down points) mean goods transport can only take place on an extremely limited basis. Where possible, a very restricted passenger transport service is resumed on fixed routes. Some passenger train stations therefore re-open. However, shops remain shut and ticket machines are still not working.

In shunt yards and terminals an attempt is made to reload goods that have been delivered to supply the population onto lorries. However, this work is very time-consuming because railway control centres and points have to be activated manually (EBP 2010, p. 114). Some railway control centres can still be operated manually, but this only enables a minimum volume of rail traffic to be accommodated. Operations control centres and external facilities are still not working, but this does not affect minimum goods transport operations.

Most of the tunnels on the supply routes have been re-opened. Corresponding journeys are regulated using written movement commands.

Points of entry to the stations and underground railway stations remain closed.

CONCLUSION

Rail traffic, operational control centres, railway control centres, safety signals and points depend on the public electricity network. Although DB Energie has long-term procurement contracts with power stations to feed traction current (electricity to operate trains) directly into the rail network, power stations in unaffected areas would be unable to compensate for the loss of electricity in the event of a prolonged and widespread power blackout. Even if this were partially possible, massive restrictions would set in once uninterruptible power supplies and emergency power systems stopped working (EBP 2010, p. 120).

Electrically powered rail transport comes to an abrupt standstill. As a result, hundreds of trains and underground trains are stranded and tens of thousands of people are trapped to start with. Some cases of slight injury result from panicked reactions and unrest. In addition, passengers who have embarked on a long walk from a stranded long-distance train exhibit signs of exhaustion. If the weather is cold, many passengers show signs of hypothermia after a few hours (caused, among other things, because heating in the trains has stopped working). From the outset, there are massive restrictions on the use of tunnels and on the functioning of operational control centres, railway control centres and safety technology. Individual tunnels are closed, railway control centre functions are performed manually where possible.

Use of most routes for passenger transport purposes remains restricted. For commuters who travel to work by train or underground train, the power blackout means a huge restriction in mobility. Switching to the car is at most only an option at the start of the blackout (shortage of fuel). However, many people are unable to work after a few days, meaning there is actually less demand in this respect.

Immediately after the power blackout train stations are able to maintain basic operations because of their emergency power supplies; however, they are forced to close after around 1 day. With some above-ground train stations this can cause problems due to technical and structural factors. Station shops close in the first hours after the blackout. Perishable goods become unusable after a few hours (loss of refrigeration).

Goods can't be transported on for further processing. It is no longer to possible to process large volumes of transport operations in the area affected. This causes economic damage throughout Germany, and also in parts of Europe.

AIR 2.2.3.3

0 TO 2 HOURS

For as long as air-traffic control doesn't prohibit passenger aircraft take-offs and landings, the power blackout has only a minor impact on flight operations. The emergency power supply ensures ground operations can continue. There are delays in passenger handling and in processing arriving and departing aircraft. The power blackout has an impact on retail business. For example, normal levels of lighting and cash register systems are not available. The consequences of the power blackout are also felt by the airport administration in this early phase. IT systems can still be closed down properly using uninterruptible power supply, keeping system crashes and data losses within limits. However, administrative tasks are already restricted.

The power blackout initially has only a minor impact on flight operations at cargo airports. Although logistics delays set in, basic functions can still be maintained. Areas which – as previously described – do not form part of ground operations experience initial difficulties in terms of functionality.

The airport control towers of Deutsche Flugsicherung (DFS), the company in charge of air-traffic control in Germany, are supplied by the emergency power systems. Their operation can therefore be ensured for the time being, at least.[58] Air traffic control tries to obtain information on the size, causes and expected duration of the power blackout in order to ascertain possible restrictions on air traffic (EBP 2010, p. 126)

The crisis units of the affected airports meet together. In addition to airport managers, these units also include representatives from the competent authorities of the federal states in which the relevant airports are located.

2 TO 8 HOURS

Flight operations reduce significantly during this phase. Although the airports affected by the blackout are still essentially able to guarantee flight operations, after just a few hours there are hardly any flight movements (EBP 2010, p. 126 f.).[59] An increasing number of flights have to be cancelled. Areas that don't form part of ground operations (e.g. catering at passenger airports, where it becomes increasingly difficult to refrigerate food and drinks) are directly affected by the power blackout. Initial falls in sales are recorded (EBP 2010, p. 126 f.).

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58 Various Deutsche Flugsicherung control centres are responsible for air traffic over Germany. DFS also operates control towers at various German airports: Berlin-Schönefeld Berlin-Tegel, Bremen, Dresden, Düsseldorf, Erfurt, Frankfurt, Hamburg, Hanover, Cologne/Bonn, Leipzig/Halle, Munich, Münster/Osnabrück, Nuremberg, Saarbrücken, Stuttgart.

59 In some cases DFS has already prohibited all take-offs and landings.

The crisis units of the airports coordinate the necessary measures. There is a marked increase in a need for information among staff, passengers and other people at the airport. There is no panic. Air carriers start to take action and divert an increasing number of flights to airports not affected by the blackout. It is unclear whether and how passengers will subsequently reach their destinations because rail travel is also badly affected.

Air traffic control has decided the degree to which flight movements will be restricted in the affected area. It continues its attempts to obtain reliable information on the power blackout. Due to the increasing failure of information and communications technologies, it becomes difficult for the DFS control towers at the airports to be involved in the crisis management process. Flights across German airspace and also take-offs and landings at airports not affected by the blackout are still possible (EBP 2010, p. 127).

8 TO 24 HOURS

Reduced operations are still possible at passenger and at cargo airports. There are significantly fewer take-offs and landings. Shops and restaurants at passenger airports are closed. The airport operators endeavour to inform staff and passengers about the state of developments because they, too, now have very few communications links that are functioning.

Air traffic control still tries to obtain the broadest possible picture of the situation. Since it is not possible to predict how much longer the power blackout will last, no further measures are decided for the moment.

24 HOURS TO 1 WEEK

Almost all restaurants and shops at passenger airports shut and heavy sales losses are incurred. Airport administration is heavily affected by the power blackout, and certain computer-based work processes are no longer possible. Communication with the outside world has come to a virtual standstill. The power blackout also affects hygiene conditions (lack of refrigeration facilities for food, no electricity in toilets, in waiting areas and administrative buildings, reduced water supply and limited wastewater disposal capability).

Due to the cancelled flights there are considerably fewer people within the airport. However, many passengers (especially foreign passengers) are still waiting for an opportunity to reach their destinations via replacement flights. For the airport managers, informing staff and passengers becomes a major challenge. Problems are encountered with airport staff. Gradually, increasing numbers of employees find they are no longer able to get to work (schools closed, safeguarding own home, transport problems). Nevertheless, some employees who are indispensable to operations must remain at the airport on a constant basis (i.e.

even overnight). Corresponding infrastructures (e.g. camp beds) are available in principle (EBP 2010, p. 128).

Once it can be seen that the power blackout will last for some time, flights are organised into the affected area in consultation between DFS and the responsible authorities in a bid to help provide the population with supplies (EBP 2010, p. 128 f.).

A LOOK AT WEEK 2

Only staff who are absolutely essential for ground operations remain at the affected airports. Shop employees, airline staff working at check-in desks and also security personnel are no longer working. For both passenger and also cargo airports, ground operations can be maintained for as long as the emergency power systems have/are supplied with sufficient fuel. The only take-offs and landings are ones for relief flights (EBP 2010, p. 129). Some airports are totally closed. Such a decision is made by DFS in conjunction with the competent department of the Land administration and the airport operator.

CONCLUSION

For the entire duration of the power blackout, emergency power systems produce the electricity required to maintain ground operations at the airport (especially all basic security-related functions) (EBP 2010, p. 131). The fuel available on the site can be used to power these generators. In terms of administration, information and communications technologies can still be shut down using the uninterruptible power supply, but will then gradually stop working. Car park barriers and lighting are no longer working, thus restricting car park usage. In some cases damage results from abandoned maintenance work, inadequate heating and low temperatures (frost damage).

Ground operations are ensured using the airport personnel planned for such incidents. However, due to the difficult transport conditions, there is likely to be a reduction in available personnel resources at the airport; employees must where necessary remain at the airport for a longer period/overnight. Travellers who arrive at the airport and those who are waiting for flights must be looked after for longer. Possibilities for onward transport are also investigated; where necessary, passengers arriving at the airport must be turned away.

Throughout the power blackout, crisis units endeavour to consult closely with DFS and the authorities to maintain ground operations at the airports and to involve the airports in efforts to manage the incident (relief flights).

As the blackout continues, the economic consequences grow because of the disruption to retail trade within the airports. The affected airports suffer extensive financial losses due to lost landing and take-off fees. The airlines also incur significant economic damage because of the losses in passenger and cargo transport. The power blackout also has tangible consequences because the airport operators in particular and also service providers based at the airport are major providers of employment for the surrounding regions.[60]

WATER 2.2.2.4

0 TO 2 HOURS

Sea ports obtain their electricity from the 110 kV grid and are therefore immediately affected by the power blackout. Loading and unloading of ships has to be suspended because the gantry cranes[61] used at the terminals cannot be operated without electricity. The power blackout brings the transhipment of goods and ferry operations to a complete standstill. The same applies to the pumping of liquid goods (e.g. oil products) and to the conveyor belts for bulk goods (e.g. coal) (EBP 2010, p. 139; Prognos 2009, p. 66).

In the harbour area, diesel-powered quayside railways[62] can still transport goods, but it is virtually impossible for goods to be transported any further on the railway network because it, too, is affected by the power blackout and all trains that depend on overhead lines come to a standstill. Lorries carrying goods can still reach and also leave the ports. However, heavy delays are encountered even here. Although the loading process can still be controlled for a certain time with the aid of an uninterruptible power supply and emergency power systems, normal operation is no longer possible because the cranes in particular are no longer working. Handling slows down and huge lorry jams build up.[63] Consequently, port managers immediately stop the transport of further goods in the port. They make contact with the corresponding companies. The fire services and police are informed as a precautionary measure. This becomes increasingly difficult due to the failures in information and communications technologies (EBP 2010, p. 139 f.).

The inland ports are also connected to the public grid and are thus immediately affected by the power blackout. The consequences are similar to those for sea ports, although the dimensions in terms of the size of the facilities and the volumes of goods transhipped are considerably smaller.

60 Frankfurt Airport alone employs over 70,000 people within the airport itself. There is also a considerably larger number of people whose jobs are indirectly dependent on the airport (www.ausbau.fraport.de/cms/default/rubrik/5/58 28.arbeitsplaetze.htm).

61 A gantry crane is a stationary, but moveable crane.

62 The quayside railways connect the transhipment terminals with the railway track network.

63 For example, 150 lorries with containers arrive at the Port of Hamburg every hour (EBP 2010, p. 139).

Seagoing vessels that are en route to the ports affected by the power blackout are informed of the situation by the port's operations control centre. Initially, it is still possible to communicate via radio and satellite telephone. To avoid handling bottlenecks, ships travelling in the North Sea or Baltic Sea anchor in the roadstead[64] and await the end of the blackout there. The power supplies of the ships themselves are ensured through separate generators. In principle, they can still enter and exit the ports. However, the radar system that manages/controls the ships suffers breakdowns, making visual navigation necessary in some cases. Overall, there is a considerable slowdown in shipping into and in front of ports.

Since loading and unloading of ships is immediately interrupted, these ships are unable to leave the ports again as planned. As there is not yet any indication that the power blackout will be a prolonged one, the shipping companies accept delays and mark time. Although the power blackout does not initially pose problems for the actual goods (e.g. special refrigeration containers will continue to cool for up to 36 hours), the delays do already cause financial damage (EBP 2010, p. 140).

Inland water vessels cannot be loaded and unloaded, either. Obstacles are also encountered entering and leaving ports. The skippers in question are informed of the problems and endeavour to reduce their speed. Inland ports offer very few opportunities for ships to anchor and await the end of the blackout (EBP 2010, p. 140).

2 TO 8 HOURS

Sea ports are no longer able to continue with either the transhipment of goods or ferry operations. Working in consultation with the competent water and shipping administrations, the harbour authority managers decide which ships can still enter the ports and which should anchor in the roadsteads in the North Sea and Baltic Sea. The managers continue to assume that the power blackout will last for a limited time and initially wait for the blackout to end.

Bottlenecks increase at the interfaces (loading and unloading stations) to road and rail transport.

The situation at the inland ports is similar to that faced by the sea ports. Some ports instruct inland water vessels to approach ports outside the affected area because waiting capacities at the ports are exhausted. Inland water vessels that could be processed have been able to leave the ports and continue on to areas not affected by the power blackout. All other ships (those that were being loaded or unloaded at the time of the power blackout and those anchored in the roadstead) continue to wait (EBP 2010, p. 141).

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64 A roadstead is an anchoring site or a mooring area in front of a port, within its breakwaters or before the mouth of a waterway.

8 TO 24 HOURS

There has been little change in the situation at the sea ports. Transhipment of goods remains at a standstill. The bottlenecks at loading and unloading stations are no longer increasing at such a fast rate because goods trains can no longer reach the port and while the mobile phone network was still functioning, many lorries were instructed by freight forwarders not to enter the ports.

At the inland ports, too, ships continue to await the end of the power blackout (EBP 2010, p. 141).

24 HOURS TO 1 WEEK

Once it becomes increasingly clear that the power blackout will be a prolonged one, the ports take measures that have been drawn up for such cases. Dealing with perishable goods that can no longer be sufficiently refrigerated or with hazardous goods becomes especially critical. The task of securing the respective harbour area assumes increasing importance. There is an increased risk of theft because security measures that depend on electricity (e.g. electric gates and fences or surveillance cameras) no longer work.

The port authorities and the competent administrative body inform the ships anchored on the roadstead that transhipment of goods will not be possible for an indefinite period. Across Europe, people start to make plans on how to divert flows of goods. This is especially problematic for container transhipments.[65] Organising onward transport is also extremely complex in logistical terms.

Since the extent of the power blackout can now be predicted, inland water vessels that are waiting to enter the ports continue their journey either upstream or downstream so that goods can, where possible, be transhipped there (EBP 2010, p. 142).

A LOOK AT WEEK 2

The sea ports affected by the power blackout can no longer carry out regular operations.[66] Where possible, the goods that are being transported by sea are diverted to other ports in unaffected regions and are transhipped at these ports.

65 For example, the capacities of the Port of Hamburg (10 million containers per year) could not be taken over by the other European sea ports at short notice.

66 In the case of the Port of Hamburg, it could be possible for emergency operations to maintain basic functioning of the port (refrigeration of containers, functioning of security facilities, handling of fewer ships, enabling these ships to leave the port). Hamburg has its own power stations that can be operated with gas or coal. If this type of operation were possible, then Hamburg and the port could be supplied with electricity on a temporary basis (EBP 2010, p. 142). However, the continuing disruptions to road and rail transport make it impossible for onward transport of containers to proceed as planned.

The consequences of the power blackout are therefore also felt at ports of the North Sea and Baltic Sea that are not affected by the blackout.

The sites of the inland ports affected and whose operations remain suspended are secured as well as possible. Almost all waiting ships have left the ports and have been diverted to other ports not affected by the power blackout (EBP 2010, p. 142 f.). The shipping companies endeavour to divert their ships to other ports. Ships that are still anchored in the roadstead because they cannot travel to alternative ports experience problems in keeping themselves supplied with (fresh) food and where applicable also with fresh water.

CONCLUSION

The infrastructures in German ports that are required for transhipping goods and containers and also for conveying people and for ferry operations either stop working immediately (e.g. cranes, conveyor belts) or after a few hours (e.g. IT and means of communication). If a network that feeds the ports fails, it is not possible to use emergency power systems to generate the electricity required for normal operations (EBP 2010, p. 139). The resulting standstill at the ports has huge implications for goods transport in particular.

In the ports themselves, damage occurs on quay walls and to pipes and there is also widespread damage to rivers if the ships back up, attempt incorrect manoeuvres and/or anchor up for a long time. Water pollution may result if ships anchored in the roadstead discharge their wastewater directly into the sea or inland water courses. If pollutants escape because goods can no longer be stored correctly, this can result in environmental pollution and in risks to health (EBP 2010, p. 143).

Sea ports represent central hubs for goods transport in particular. The backlog of goods means shortages of certain products will develop as the power blackout continues (EBP 2010, p. 148). Whereas the loss of inland ports has a mainly regional effect, the loss of sea ports is felt throughout Germany and even across Europe. For example, the loss of the Port of Hamburg – which alongside Rotterdam and Antwerp is one of the biggest container ports in Europe – will have far-reaching consequences for value creation within the national economy, for the flow of goods across regions and for logistics chains.[67] Normal processes and smooth interaction of the supply chains and of production that depends on such supply chains will not be fully restored until long after the end of the power blackout.

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67 A considerable number of jobs are directly or indirectly attributable to economic processes at ports. For example, at the Port of Hamburg alone, around 100,000 jobs depend on container transport (www.hafen-hamburg.de/de/content/hpa-investiert-langfristig-wettbewerbsf%C3%A4higkeit-des-hamburger-hafens-westerweiterung-eurogat). Nationwide, 276,000 jobs are indirectly linked to the Port of Hamburg (EBP 2010, p. 148 ff.).

WATER SUPPLY AND WASTEWATER DISPOSAL 2.3

Water is a non-substitutable foodstuff and guarantees minimum standards of hygiene; as such, it is an indispensable resource for meeting basic human needs. At the same time, water is also of major importance for trade, the retail sector, industry and public institutions. For example, when used as a coolant, extinguishing agent and processing agent and also as a raw material, it is an essential input and production factor.

Water infrastructure systems (i.e. water supply and wastewater disposal systems) are complex technical systems that permit the simultaneous provision of different services. Among other things, such infrastructure systems are used to provide drinking water and fire-fighting water and also to divert drain water and rain water from private and public areas, for community sanitation and for water pollution control. The water infrastructures established within Germany over the last century generally involve systems with a centralised structure. Distribution and discharge is organised via widely ramified pipe networks. The dimensions of the supply pipe network are based on demand, which is determined by drinking water consumption and required reserves of fire-fighting water.

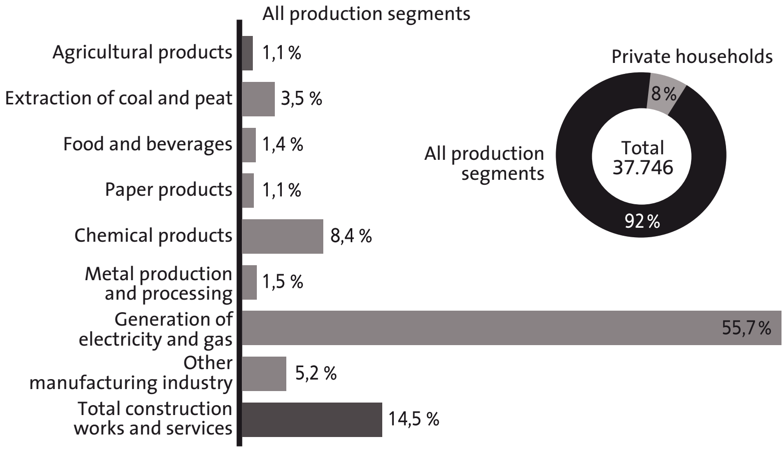
WATER SUPPLY AND WASTEWATER DISPOSAL INFRASTRUCTURE 2.3.1

In 2007, around 5,100 million cubic metres of water were available for the public drinking water supply in Germany (this figure excludes 52.3 million cubic metres from other countries). On average, each inhabitant consumes 122 litres of drinking water per day, although consumption varies widely between the federal states. The proportion of the population supplied with water through the public drinking water supply is 99.2 % (Statistisches Bundesamt 2009).

The total volume of water removed from the natural environment each year is far higher than the quantity made available for the public drinking water supply. Figure 15 provides an overview of usage with a corresponding breakdown by segment.

As services of general interest, water supply and wastewater disposal are the responsibility of local self-government. They require an infrastructure that includes both technical facilities such as water works and distribution networks and also organisational concepts, safety and risk concepts, employment of staff, tariff arrangements and service offerings. The local authorities are given freedom to design the institutional and organisational structures. They may use the services of private companies. In most cases, water supply and wastewater disposal are organised by separate bodies.

FIGURE 15 WATER USAGE FOR ECONOMIC ACTIVITIES (2007)



Source: Statistisches Bundesamt 2009; the figures relate to the total volume removed from the natural environment (40.5 billion cubic metres)

The following section examines both direct consequences of the power blackout on the infrastructure itself (Chapters III.2.3.3 and III.2.3.4) while also providing examples of resulting (i.e. indirect) effects of the power blackout on dependent systems. Direct consequences for the public are also considered (Chapter III.2.3.5). Prior to this, the functions and technical elements of the water supply and wastewater disposal infrastructure are presented, with particular emphasis on their reliance on electricity; an overview of statutory provisions is also provided.

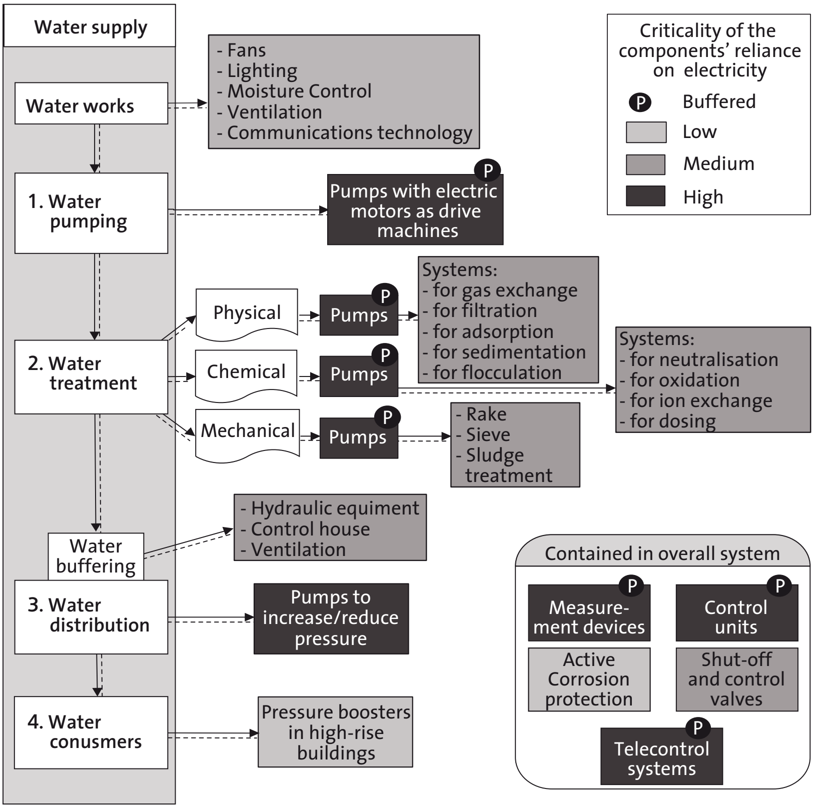
WATER SUPPLY 2.3.1.1

Water suppliers are tasked with supplying high-quality water to private households, industry, service providers and public institutions (Mutschmann/Stimmelmayr 2007). This requires an infrastructure that includes technical facilities such as water works and distribution networks (Figure 16).

PUMPING

In Germany, the majority of drinking water (61.9 %) is obtained from groundwater (Statistisches Bundesamt 2009). Water works use different types of electric pumps to pump the water (BOKU 2008). Constant monitoring and control (e.g. of pressure, engine speed and throughput) is necessary to ensure continuous pumping of water (Ebel 1995; Grombach et al. 2000; LfU Bayern 2010). This is done via remote control systems or using local process, measuring and control technology (Mutschmann/Stimmelmayr 2007).

FIGURE 16 OVERVIEW OF TECHNICAL ELEMENTS IN THE WATER SUPPLY AND THEIR DEPENDENCE ON ELECTRICITY



Own image

Dependence on electricity

Pumps and process, measuring and control technology constitute integral components of pumping installations and obtain their electricity from the public grid; emergency power generators are often available to bridge power blackouts.

WATER TREATMENT

Water treatment involves processing the natural water to create drinking water, taking into account the provisions of the Drinking Water Ordinance (TrinkwV). This includes cleaning, softening, desalination, iron removal, demanganisation and sterilisation on the one hand and on the other hand adjusting properties such as the pH value.

The processes used generally depend on the quality of the natural water. Treatment includes physical, chemical and biological processes such as the use of grills and sieves, sedimentation, oxidation and neutralisation (Mutschmann/Stimmelmayr 2007).

Dependence on electricity

Electric pumps that feed the water through the individual processing stages form an integral part of the water treatment process. Monitoring and control equipment is also essential. Electric components are also used in the sedimentation tanks and sand filter detention basins and in the mechanical flocculation plants, agitators, sludge rakes and flotation plants, air compressors and scum rakes. Membrane filter systems and electrodialysis filters also require electrical power (Grombach et al. 2000). Processing media for water treatment are transported for use via conveyor belts, pumps and hydraulic systems in combination with dosing systems (Ebel 1995). If ozone is used for disinfection purposes, the necessary ozone generators require large quantities of electrical power.

WATER DISTRIBUTION

The water distribution system acts as the link between the water works that treat the water and water consumers; it includes the distribution and storage of water and also maintenance of operating pressure.

Distribution as such takes place via a fixed system of installed pipes, the structure of which varies greatly between the different regions in Germany (e.g. ramified or interconnected network structure). The piping network is operated using a pressure of between 4 and 6 bar, with either elevated tanks and/or pumps used to maintain this pressure.

Water storage plays a major role in the distribution process because it ensures a constant supply despite peak loads or temporary malfunctions (Grombach et al. 2000; Sattler 1999). Water is stored in elevated tanks or in water towers, which must be designed to ensure they do not impair drinking water quality. Generally, the dimensions of water storage facilities are designed for daily equalisation, meaning that if power failures occur, the period for which supplies can be maintained depends on the fill level at the moment the blackout occurs (Finkbeiner 2009).

Dependence on electricity

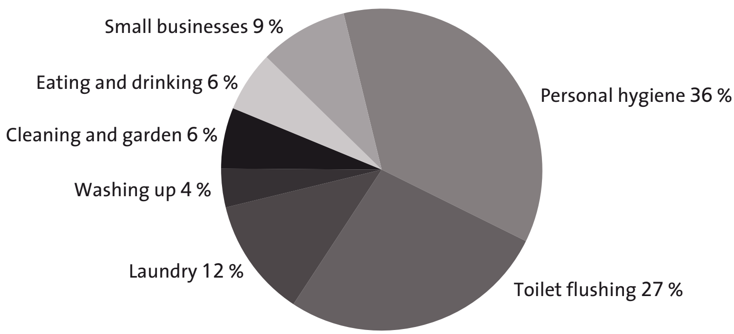
Electric pumps are a key component of the distribution network. Monitoring and control equipment is especially important in an extensive network. For example, the remote control systems require electrical power for data storage and for process, measuring and control technology (Sattler 1999). They also depend on public telecommunications networks, which are no longer available after a certain time during a power blackout (Chapter III.2.1).

WATER CONSUMERS

Water consumers include industry, private households and public institutions. The composition of private consumption is shown in Figure 17.

Extraction of drinking water from the distribution network requires a pipeline pressure that even allows extraction in buildings located in elevated positions or on higher storeys of buildings; 1 bar represents a height of around 10 m.

FIGURE 17 COMPOSITION OF PRIVATE CONSUMPTION



Source: DVGW 2008b

Dependence on electricity

Electricity is vital for operating the pumps in booster stations such as those used in high-rise buildings. Beyond this, electricity is only required to prepare the water for further use (e.g. heating by means of continuous-flow heaters).

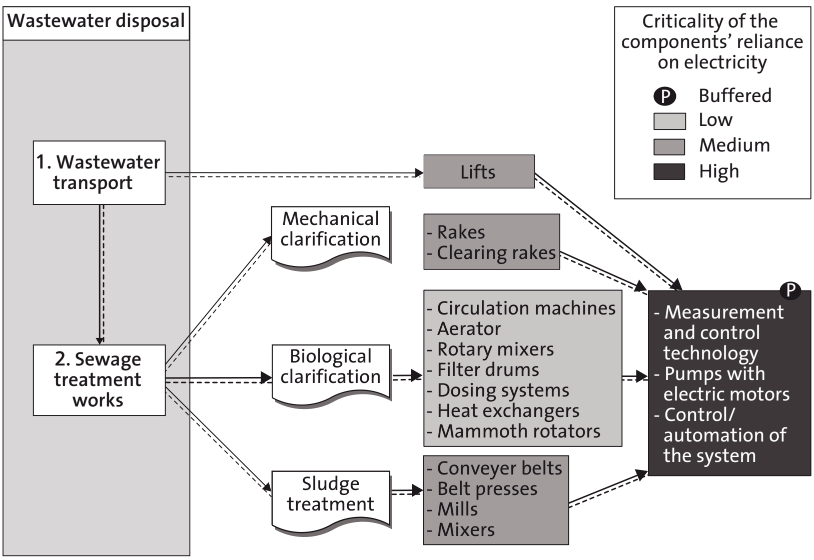
MISCELLANEOUS

Water works require moisture proofing due to the high humidity levels. Drying agents and moisture condensation processes are used, and also fans in some cases. Water works also require corrosion protection; the external current cathodes require electrical power. Increasing automation of water works requires the use of remote control, information and communications technology to ensure the primary processes can also be monitored and controlled from a distance. This creates an increasing dependence on electricity (Ebel 1995).

WASTEWATER DISPOSAL 2.3.1.2

Wastewater is disposed of by collecting and discharging the wastewater, via the sewage system, into central treatment plants and by discharging the cleaned wastewater into surface waters. The wastewater to be disposed of also acts as a transport medium; consequently, faecal transport in the sewage system requires a functioning water supply infrastructure (Chapter III.5.2). Figure 18 provides an overview of the technical elements. Germany has around 10,000 sewage treatment plants that treat an annual wastewater volume of around 10 billion cubic metres; this is almost exclusively based on biological processes. The proportion of households connected to the wastewater system is around 96 %.

FIGURE 18 OVERVIEW OF THE TECHNICAL ELEMENTS IN WASTEWATER DISPOSAL AND THEIR DEPENDENCE ON ELECTRICITY



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COLLECTION OF WASTEWATER

In 2007, Germany's public sewage network had a length of approximately 541,000 km. At 44 %, combined storm and sanitary sewage systems account for the majority of the network, followed by separate sewer systems (35 %) and rainwater sewage systems (21 %) (Statistisches Bundesamt 2009). These also include special drainage systems such as pressure or vacuum drainage, which are used where special underlying conditions apply (e.g. very flat ground and/or low population density). The different drainage systems have advantages and disadvantages that make them more or less suited to different underlying conditions. In the case of combined storm and sanitary sewage systems, rainwater can be used to flush the sewers and remove deposits.

Dependence on electricity

In gravity sewer systems, the relevant power-dependent systems include pump facilities and measuring equipment (e.g. to measure flow rate). In pressure/vacuum systems, electrical power is essential for maintaining the transport of wastewater.

WASTEWATER TREATMENT PLANTS

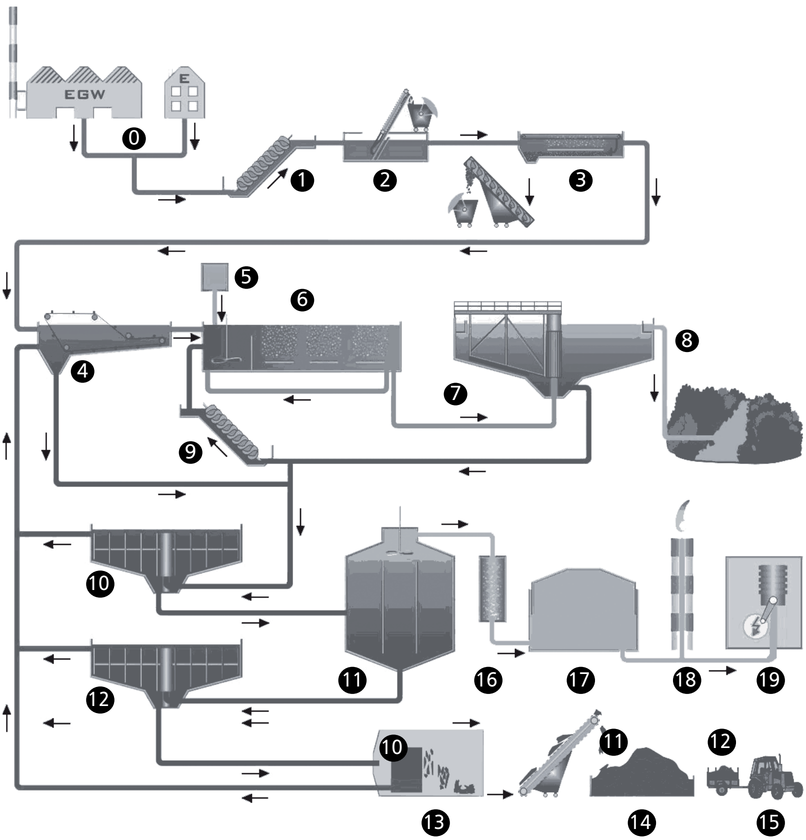
Wastewater treatment plants (also known as sewage treatment plants) are designed to treat wastewater with a view to returning it to natural watercourses. In Germany, wastewater is cleaned using three stages – mechanical, biological, and transportation. The main functions of a wastewater treatment plant are shown in Figure 19 and the corresponding functions are outlined in Table 5.

Sewage treatment plants can supply their own electricity and heat by producing biogas and converting it into electricity; to date, this process has mainly been used at large municipal plants. In Germany, around 1,200 sewage treatment plants (around 12 % of all sewage treatment plants) currently have facilities for producing digester gas. 63 % of plants also have combined heat and power plants in which around 80 % of the gas volume produced is converted into electricity.

Another way in which sewage treatment plants can contribute to energy self-sufficiency is by using the digester gas themselves to power heating installations within the power plants. Nationwide, 20 % of digester gas is already used for this purpose, although in some cases this involves pure thermal conversion (UBA 2008). Due to the simultaneous need for electricity and heat in sewage treatment plants, the use of combined heat and power plants makes particular sense because all the energy produced by digester gas is used.

Ensuring a network-independent power supply through the production of autonomous energy is also particularly appropriate for wastewater plants because it would improve their resilience to power blackouts; the possibility of uninterruptible switching to autonomous energy should be considered (Chapter IV.6).

FIGURE 19 PLAN OF A WASTEWATER TREATMENT PLANT



Source: Landesabteilung Umwelt, Bozen/Südtirol, www.provincia.bz.it/umweltagentur/wasser/1265.asp, accessed on 8 April 2010

TABLE 5 FUNCTIONS OF A WASTEWATER TREATMENT PLANT

No.	Function	No.	Function
0 & 1	Collected wastewater is fed into the sewage treatment plant via a pump	11	Digestion tank for anaerobic sludge stabilisation
2	First mechanical cleaning stage: raking and/or screening plant	12	Thickener (separation of water)
3	Sediments and fats are siphoned off in the sand filter	13	Mechanical dewatering of the sludge
4	Organic substances are separated off in the primary sedimentation tank; after this process, one-third of the pollution load has already been removed	14	Composting
5 & 6	Trickle filter (5) or activated sludge tank (6): degradation of organic substances	15	Substrate for co-incineration or agricultural use
7	Secondary sedimentation tank: siphoning off of sludge	16	Transport of the gas
8	Discharge into watercourse	17	Storage of the gas
9	One-third of sludge returned to 5 or 6	18	Combustion
10	Pre-thickener: sludge is thickened	19	Power generation

Source: Landesabteilung Umwelt, Bozen/Südtirol, www.provincia.bz.it/umweltagentur/wasser/1265.asp, accessed on 8 April 2010.

STATUTORY REGULATION 2.3.2

In Germany, the framework conditions for the water sector are determined by EU, federal and state legislation, and by corresponding statutory instruments. These include the European Water Framework Directive, the federal Drinking Water Ordinance (TrinkwV) based on the Federal Water Act, the Waste Water Charges Act (AbwAG) and the Law to Safeguard the Water Supply (WasSiG), along with the state laws on water and wastewater. Within the framework of local self-government, these laws are specified in more detail in state legislation and especially in municipal legislation. According to Section 4 [1] of the Drinking Water Ordinance (TrinkwV), the supply of water must comply with the generally accepted codes of practice. These are, for example, contained in the technical rules of the German Technical and Scientific Association for Gas and Water (DVGW) and are thus authoritative when implementing statutory provisions. The technical rules of the German Association for Water, Wastewater and Waste (DWA) have the same function in the field of wastewater.

The Drinking Water Ordinance (TrinkwV) aims to protect human health, to guarantee people's ability to enjoy water and to guarantee the cleanliness of water for human usage. In addition, the Drinking Water Ordinance obliges water suppliers to draw up plans for measures in the event of acute threats to health (e.g. where threshold values are exceeded) in consultation with the public health authorities. According to DVGW worksheet W 300, water storage facilities in the supply areas must hold a volume of water sufficient to provide supplies for at least 24 hours (DIN/DVGW 2005). Prior to the publication of notifications W 1001 and W 1002 in 2008, DVGW technical notification W 1050 »Contingency Planning for Emergencies in the Public Drinking Water Supply« applied to emergencies (e.g. triggered by acts of sabotage or natural disasters). The subsequent new notification W 1002 »Safety of the Drinking Water Supply – Organisation and Management in a Crisis Scenario« contains some more specific details. However, both sets of technical rules do not differ greatly in terms of practical counter-measures.

The Ordinance Stipulating the General Terms and Conditions Governing the Water Supply (AVBWasserV) obliges the water supply companies to make the agreed quantity of water available at the end of the connecting pipe at all times. Exceptions are largely permitted in cases of force majeure and/or circumstances which the companies cannot, from a financial point of view, be expected to rectify. As with the Drinking Water Ordinance (TrinkwV), the ordinance does not specify any requirements concerning the provision of emergency power generation capacities. Fitting of emergency power generators is addressed in DVGW worksheet W 610 »Pumping Systems in the Drinking Water Ordinance« (DVGW 2010). According to this document, »pump systems with high availability requirements« should be fitted with emergency power generators, the fuel tanks of which should be of an »adequate« size. Alternatively, pump systems can, according to the worksheet, also be equipped with a connection facility for mobile emergency power generators. However, the worksheet does not contain any more detailed specifications on which pumps are deemed critically important for the functioning of the infrastructure; similarly, no statements are provided on how this should be ascertained.

The Law to Safeguard the Water Supply (WasSiG) and its associated statutory instruments (AVWasSG) regulate safeguarding the supply of the civil population and the armed forces with drinking water, service water and fire-fighting water in a state of defence. The facilities created under this framework may also be used in other crisis and disaster situations during peacetime (BBK 2008c). Moreover, the Law to Safeguard the Water Supply (WasSiG) also covers the discharge and treatment of wastewater to avert risks to health, although no specific requirements or recommendations are stipulated. On the basis of the Law to Safeguard the Water Supply (WasSiG), the Federal Government is, among other things and with the consent of the Bundesrat, authorised to issue requirements concerning the equipping of water supply and wastewater disposal facilities. Pumps, emergency power generators and facilities for distributing and treating water are mentioned explicitly. Among other things, a nationwide system of around 5,200 emergency wells has been established for the purposes of supplying water in disaster situations (Chapter III.2.3.5).

In principle, the same legal requirements apply to the field of water supply in a disaster as during normal operations. In a disaster scenario, the health authorities of the Länder can issue emergency response directives on the basis of the Act on the Prevention and Control of Infectious Diseases and on the basis of the Drinking Water Ordinance (TrinkwV). In addition, Länder police and regulatory laws give the police and the authorities responsible for law and order authority to intervene in urgent cases.

CONSEQUENCES FOR THE WATER INFRASTRUCTURE AND EMERGENCY OPERATION 2.3.3

The following section uses a time frame to outline the direct consequences of a power blackout for the supply and disposal infrastructure.[68] Most of the storage facilities available in the networks and in plants for both electrical power and also for drinking water and wastewater are designed to bridge short interruptions to supplies (i.e. lasting less than 1 day). To enable the processes to be recorded on the basis of time, it is therefore appropriate to use a system of categorisation focussing on the first few hours. The time frames for the discussion are 0 to 4 hours, 4 to 8 hours, 8 to 24 hours and more than 24 hours (see the following Tables 6 and 7).

Within Germany, the consequences of a power blackout on the water infrastructure systems and on the crisis management capabilities of the water supply and wastewater disposal companies reveal major geographic variances; this makes any prototypal measurement and description extremely difficult. This is firstly due to the structure of the statutory regulations, which place responsibility for elaborating emergency plans and for ensuring supplies on the cities and local authorities. Secondly, local conditions are a major factor in determining the characteristics of the direct effects of a power blackout on supply and disposal systems. For example, equipping facilities with emergency power generation capacities, the provision of emergency power feed points, equipping facilities with network-independent communications technology and also topographic parameters such as gradients in

68 Explorative guided interviews were conducted on the subject matter. The interview partners were from the fields of disaster control (Federal Office of Civil Protection and Disaster Assistance) and from water supply and wastewater disposal companies. When selecting the interview partners from the companies, an attempt was made to cover different supply structures and different-sized companies.

the pipeline system all play a role in terms of response capabilities. This heterogeneity makes it difficult to apply findings from random interviews with operators on a generalised basis to over 6,200 water supply operators and 6,900 disposal operators within Germany (Statistisches Bundesamt 2009).

CONSEQUENCES FOR THE WATER SUPPLY 2.3.3.1

Water supply operations cannot continue on a long-term basis without electrical power. It is only possible to bridge a comparatively short period of a few hours to up to 1 day by using elevated tanks to generate pressure, provided such tanks are available in the network. The storage volumes that are geared to daily consumption in the supply area and designed to cover the fire-fighting water reserve vary from supplier to supplier. On average, suppliers can cope with supply disruptions lasting less than 1 day. However, it is possible to supply water with the aid of emergency power generators. Consequently, emergency feed devices are often provided at key points in the network such as water works (and wastewater treatment plants); emergency power generation capacities are also often installed. The achievable level of performance depends firstly on the available emergency power generation capacity and secondly on the scalability of the systems and processes (i.e. the ability to operate these at a different – in this case lower – level of performance). According to experts, the performance level and thus the energy consumption of water works can be reduced relatively easily, even if technical elements do not necessarily work at optimum efficiency when performance is reduced. Emergency operation at a level of 30 to 60 % is perfectly conceivable. Operators aim to achieve this level in order, for example, to prevent major hygiene problems developing in conurbations.

Even though it is not possible to guarantee full drinking water quality, water is available for a number of uses by consumers. In many cases, consumers can ensure potability by using disinfectants or by »boiling«. However, this requires a corresponding communications strategy to inform the public; moreover, the pipeline system may require expensive cleaning measures when normal operations resume.

Where available in the network, remote process, measuring and control systems are often electrically buffered meaning they can continue to be operated for a few hours. After this time, the data required for operating the network such as the fill level of the elevated tanks and the pipeline pressure must be ascertained manually and communicated to the operations control centre.

A power blackout has direct consequences for all electrically operated elements within the infrastructure. Equipment and systems that are not buffered by an uninterruptible power supply fail immediately. If an uninterruptible power supply is available, systems can be shut down in a controlled way, thus avoiding possibly irreversible damage (e.g. through the loss of data in IT systems).

TABLE 6 CONSEQUENCES OF POWER BLACKOUTS FOR THE WATER SUPPLY

Water supply	0 to 4 hours	4 to 8 hours	8 to 24 hours	More than 24 hours
Pumps	Pumps without an emergency power supply stop working			Shortage of fuel for emergency power generators[1]
Process, measuring and control facilities in the water works	Process, measuring and control facilities without an emergency power supply stop working		Process, measuring and control facilities with battery back-up stop working[2]	
Treatment plants	Treatment plants without an emergency power supply stop working			
Heating/light/ventilation/etc.	Stop working if no emergency power supply		Internal radio network stops working	
Distribution/consumption/storage	Booster stations without an emergency power supply stop working	Reduction in water pressure, water supply in the external areas of the network fails	Reduced drinking water in stagnant drinking water, water buffers run empty	Storage facilities can no longer be filled
Remote control systems in the network	Remote control systems without an emergency power supply stop working		Company telephone systems with battery back-up stop working[2]	

1 Supplies suffice for around 5 days
2 Availability approx. 10 hours

Own image

Depending on the connection rate of power-supply-dependent components of the facilities/systems and on the generation capacity of the emergency power network, it is possible to continue operating the infrastructure at part load. Where available, pumping stations that are designed to increase pressure in the distribution network often obtain their energy from the public electricity grid. In many cases, no direct provision is made for an emergency power supply and this may first have to be installed if required. If these pumps fail it is in principle possible to continue operating with reduced pressure. However, this may reduce the availability of water in the distribution network (e.g. water can no longer reach the upper storeys of high-rise buildings). A temporary loss of network pressure creates a risk of air pockets in the network or of damage caused by pressure surges.

CONSEQUENCES FOR WASTEWATER DISPOSAL 2.3.3.2

With wastewater disposal and treatment, the main dependence on electricity revolves around the pump and lift stations in the sewage system and the operation of the sewage treatment plants by means of electrical components such as pumps, agitators, ventilation systems and process, measuring and control technology as a whole. Wastewater lifting pumps often have no emergency electricity back-up, meaning wastewater that is produced can leak from the sewage pipes if pumping power is insufficient. However, the power blackout in the Münsterland in 2005 revealed that even unconventional solutions can work with small and medium accumulations of wastewater. Mobile emergency power generators and pumps were used to empty the wastewater tanks of the lift stations and the contents were transported to the nearest sewage system entry point by means of slurry tankers. From here, the pipe gradients then enabled transport to the sewage treatment plant.

During a power blackout, the volume of dirty water is likely to fall because it will probably be impossible to maintain the water supply at normal operational levels and because the public will in many cases only have cold water available. Moreover, the composition of dirty water is likely to change. Since there is likely to be a reduction in water usage for personal hygiene purposes, the thinning effect of water from showers is removed, making the wastewater more concentrated. There is therefore a danger of increased formation of deposits in the sewage system and of associated problems caused by blockages, odour formation and disease carriers such as rats. In combined sewer systems, rainwater may act as an additional thinning agent and transport medium.

The fall in the volume of wastewater enables the performance of the wastewater treatment plant to be reduced, while a higher concentration of wastewater may produce an opposing trend. Reduced power consumption reduces the need for emergency power and fuel. It is possible to scale performance at plants with multiple process lines where the volume of wastewater is distributed across process lines that are operated in parallel to each other; this allows individual process lines to be switched off separately.

Sewage plants are generally equipped with emergency power supply capacities that allow full-load operation. If the emergency power supply stops working, operations can no longer continue. Since electric pumps constitute integral components, the plants cannot be operated without electricity. Although some volumes of wastewater can be stored in mixing and equalisation tanks which serve to level out daily fluctuations and ensure equal loading of the plant, this cannot be done for large quantities or for periods lasting much longer than 1 day. If the plant comes to a standstill the volumes of wastewater are fed directly into surface waters without passing through the sewage treatment plant. This inflicts direct damage on the environment.

TABLE 7 CONSEQUENCES OF POWER BLACKOUTS FOR WASTEWATER DISPOSAL

Wastewater disposal and treatment	0 to 4 hours	4 to 8 hours	8 to 24 hours	More than 24 hours
Sewage system	Lifting pumps without an emergency power supply stop working			Shortage of fuel for emergency power generators[1]
Process, measuring and control systems and information and communications technology in the sewage treatment plant	Technology without battery back-up stops working	Battery-powered technology stops working[2]		Shortage of fuel for emergency power generators[1]
Cleaning stages in the sewage treatment plant	Equipment and facilities without an emergency power supply (e.g. mechanical cleaning and ventilation systems) stop working		Temperature undershoot in nitrification	Shortage of fuel for emergency power generators[1]

1 Supplies suffice for around 5 days
2 Availability approx. 10 hours

Own image

PROBLEMS ASSOCIATED WITH AND STRATEGIES FOR RESUMING OPERATIONS 2.3.4

The following section provides an overview of strategies for and possible problems associated with the resumption of water infrastructure system operations. Re-starting the systems can take a long time for technical and organisational reasons. Efforts to ensure a fast and efficient recovery process are especially important for water infrastructure systems because once the power blackout has come to an end, a functioning water supply and wastewater disposal system can help other infrastructure systems and also the general public to return to an orderly existence.

WATER SUPPLY

With regard to the water distribution system, experts do not predict any irreversible damage to structures or equipment under normal circumstances. However, due to air pockets and the risk that contamination may have occurred, it is highly likely that an extensive, time-consuming and labour-intensive disinfection and flushing procedure will be required when restarting the supply infrastructure (Wricke/Korth 2007). Although fewer flushing processes are now performed in the networks because measuring probes allow the water quality to be constantly checked at many points in the network thus avoiding the need for prophylactic flushing procedures, all operators are of the opinion that sufficient corresponding experience is available.

During the re-start process care must be taken to ensure that the load on the network does not become too high as this could create a risk of pipe ruptures.[69] In this context, the general public and water consumers must be included in a communications strategy.

WASTEWATER DISPOSAL AND TREATMENT

Increased deposits of sand and faecal matter are likely in the sewage system, resulting in a need for flushing measures when normal operations are resumed. The disposal companies have corresponding experience in such measures. Flushing measures necessitated by reduced water consumption and demographic change are becoming an increasingly frequent element of operations and maintenance work.

Irreversible damage to concrete pipes caused by, for example, hydrogen sulphide corrosion, is not likely to occur within a period of 4 to 6 weeks.

Power blackouts of 6 to 8 hours are not critical to the recovery process in wastewater treatment plants. In such cases, a period of around one hour is required to restore full operational readiness. Even after being shut down for 4 to 5 days (without electricity and further input of sewage material), resilient sewage treatment plants can be re-started without major difficulties because the bacteria cultures used can survive such periods. However, if the shutdown lasts any longer, the bacteria cultures must be re-cultivated and re-introduced to the plant.

69 This occurred in July 2007 following a failure of the water supply in parts of Hamburg as a result of an incident at the Krümmel nuclear power plant (personal statement by an employee of the BBK, 6 July 2010).

Nevertheless, irreversible damage to the plant's technical elements is unlikely, and operations can in principle be successfully organised once wastewater input is re-started following a power blackout. The plants are generally designed to cope with large fluctuations in the volume of sewage material; consequently, re-starting operations if the bacteria population is intact, although decimated, can be considered as an extreme case of such fluctuations and can be successfully overcome.

INDIRECT CONSEQUENCES EMANATING FROM THE WATER SUPPLY AND FROM WASTEWATER DISPOSAL 2.3.5

In addition to the direct consequences for the water infrastructure itself, a power failure also has indirect consequences associated with the water infrastructure systems. Breakdowns or disruptions affect those areas of the infrastructure and society that depend on the reliable provision of water infrastructure services. The following section discusses indirect consequences using the example of three key functions of water as a resource: Water as a food, water as an extinguishing agent and water as a transport medium in the sewage system.

WATER AS A FOOD

During a prolonged power blackout it is essential to ensure a supply of drinking water for the population. The extent to which and the length of time for which a pipe-based supply of drinking water can be maintained depends on many conditions, not least on the ability to supply fuel for emergency power generation.

If the pipe-based supply of drinking water is maintained at a low level of performance, operations based on a low pipe pressure can firstly lead to a reduction in the number of households supplied with water; secondly, if quality requirements for the treatment of natural water are reduced, this can lead to water being supplied below the quality standard for drinking water. In the first case, alternative sources for the supply of water must be secured. In the second case, consumers can take measures to treat water and thus make it potable (boiling and the addition of chlorine and/or silver ions).

An interruption to the water supply has an extensive impact on domestic life. It becomes impossible to maintain normal levels of personal hygiene, the ability to prepare food and drinks is restricted, washing up and other forms of cleaning work are not possible or are only possible to a limited degree, washing machines don't work and toilets can't be flushed. Plants can't be watered. The longer the blackout lasts, the more pronounced the problems are likely to become. People soon run out of clean clothes, toilets may become blocked and there is a further decline in personal hygiene. There is an increased risk of outbreaks of disease (e.g. through an increase in disease carriers, parasites and pests that are able to penetrate living areas more easily).

Under such circumstances, water is highly likely to assume such paramount importance that providing a water supply becomes one of the most important tasks during the disaster. The importance of alternative sources of water increases dramatically.

- Germany has around 5,200 wells designed to supply the public with drinking water during crises and disaster situations. The Federation administers the emergency wells and is responsible for investments. The Länder are responsible for their operation and maintenance and fulfil this task at the level of municipal administration. The wells are independent of public networks and are designed so that they are protected against damage and pollution. The water can be made available at corresponding standpipes and can be transported by the public using buckets or canisters. To ensure that minimum hygiene standards can be met and that meals can also be prepared, a figure of approximately 15 l per day and per person is used as a basis in Germany when designing emergency wells; an emergency well is designed to operate for 15 hours a day with an average extraction volume of 6 cubic metres per hour. However, numerous wells also have an output rate of 20 cubic metres or more per hour. For wells with a sufficient groundwater level and an output rate of 3 cubic metres per hour, the Second Ordinance to Safeguard the Water Supply stipulates that hand pumps must be provided in most cases. Otherwise, a combination of pumps and engines should be used. Where electric engines are used provision must be made for an emergency power supply feed. The water quality of the emergency wells is checked on a regular basis. Where necessary, a disinfection procedure is carried out using chlorine tablets, which are kept in stock for all wells (BBK 2008c).
- In addition, the public can be provided with water that is not supplied via pipes by transporting it by lorry in »packaged« form. For example, the Berlin water works have a facility for packaging drinking water in pouches, enabling the water to be stored for long periods. Electrical power is, however, required to operate the machinery; consequently, packaged water must always be kept in stock to cover a disaster situation and must be replaced once it reaches its expiry date.
- A similar concept could involve using resources of bottled-water producers and beverage-filling companies. Working in cooperation with water works and provided the plant could be supplied with power or was outside the affected area, drinking bottles could be filled with water and the producer's logistics system used to effect deliveries.

WATER AS AN EXTINGUISHING AGENT

In Germany, the supply of fire-fighting water is the responsibility of cities and local authorities and includes facilities for making fire-fighting water available; the relevant rules are set down in DVGW worksheet W 405 (DVGW 2008a).

The fire-fighting reserve is included when calculating the size of the water supply capacity of the drinking water network for a supply area. Corresponding calculations reveal that an inhabitant figure of around 15,000 represents the tipping point between the amount of water required by households and the required fire-fighting reserve. Below this threshold, more fire-fighting water than consumption water and drinking water is required, while the pattern is reversed above this figure. The quantity of water stored in the drinking water distribution system must be calculated based on 2 hours' use for fire-fighting purposes with at least 24 cubic metres per hour (Berufsfeuerwehr Braunschweig 2009; DVGW 2008a). No extraction point within the network should dip below a pressure of 1.5 bar (Freynik 2009).

Different extinguishing agents are used for fire-fighting depending on the situation and requirements. These agents include water, foam, powder and inert gases. Fire-fighting water is defined as »water« or »water with additives« that is used for cooling purposes (DIN 14 011 part 2, draft 1991, No. 2.7). At the same time, due to its effective cooling capacity, the comparatively low costs and high availability, water is the most important extinguishing agent used for fighting fires.

When referring to the supply of fire-fighting water, a distinction is made between water that is dependent on the pipeline system and water that is independent of pipelines. With water that is dependent on the pipeline system, the fire-fighting water is taken from the drinking water distribution system via hydrants that are distributed across urban areas on an even and frequent basis. Fire brigades take supplies of network-independent water from extraction points in watercourses and standing water bodies and from extraction points at specially created fire-fighting ponds and cisterns. Fire brigades must work on the principle that natural water sources should be used in preference to drinking water from the distribution network. However, stream courses must, for example, have a minimum depth to enable the suction pieces of the delivery pumps to collect the water. In practice, the drinking water supply network is often the only available source of fire-fighting water in urban environments.

The extraction of fire-fighting water and its transport to the site of a fire depend on the equipment installed at the extraction stations and on the fire-fighting vehicles. Usually, the fire brigades bring pumps to the extraction site and must ensure a supply of power to the pumps. The basic rule for fire engines is that they must carry a power reserve for a distance of around 400 km. This corresponds to around 4 hours of extinguishing operations for a vehicle.

If no or insufficient quantities of fire-fighting water are available at the site of the fire, a supply must be established via a system of hoses and pipes, or using tankers operating in a shuttle service. Setting up long supply lines is time-consuming and depending on length, requires a number of interconnected pumps. Greater recourse must be made to alternative water resources in areas where the pipe system is not sufficiently well developed. This requires adequate mapping and information on approach routes and capacity.

A general power blackout will on the one hand probably result in fewer fires caused by short circuits in everyday electrical devices. On the other hand, however, there is a risk of additional fires breaking out in the industrial sector as cooling and process control systems stop working. During a power blackout, the use of alternative mains-independent means of generating heat for heating and cooking purposes and for lighting leads to an increased fire risk because many such means rely on the use of naked flames (gas and spirit stoves, ovens and charcoal grills, tea lights, candles or oil lamps).

Fire-fighting in rural and urban areas is heavily geared to the use of water as a coolant and extinguishing agent without the special use of high-pressure and dispersion methods. In rural areas, the supply of fire-fighting water is less geared to the provision of fire-fighting water via the drinking water distribution system than to alternative water sources such as water tanks, standing water bodies and water courses. In the event of a power blackout, therefore, fire brigades in rural areas are less dependent on a working supply via the water infrastructure. In urban environments the distribution density of alternative sources of fire-fighting water is much reduced, resulting in a comparatively high dependence on an intact drinking water supply. Moreover, the high population density creates a risk of fire breaking out in apartment blocks and possibly even across whole districts. Fire-fighting water is thus a critical resource in urban areas.

WATER AS A TRANSPORT MEDIUM

Water-borne sewage systems, which represent the main type of system used for wastewater disposal, require the use of water as a transport medium. Generally, sewage systems are designed for a drinking water consumption of 130 to 150 l per person per day. A decline in the water supply and thus in water consumption as a result of a power blackout leads to a fall in dry weather flow.

This can trigger various operational changes and problems (BMVBS/BBR 2006; Winkler 2006):

- Deposits and blockages in the sewage network,
- Degradation of organic substances (»foul« wastewater),
- Build-up of corrosive gases (H_2S), risk of concrete corrosion,
- Odour problems, problems caused by disease carriers (e.g. rats).

In sewage networks, H_2S builds up where anaerobic conditions prevail for long periods. In practice, this often occurs at transfer points where pressure pipelines feed into gravity sewers.

To prevent/reduce blockages in the sewage networks and the associated hygiene problems, water suppliers and wastewater disposal companies endeavour to maintain supplies on a constant basis, even if full drinking water quality cannot be guaranteed under normal conditions.

For private households, the restriction in the ability to dispose of faecal products becomes a major problem. Toilets cannot be flushed due to a lack of flowing water in the cistern. Although toilets can also be flushed by pouring water down them, the volume of liquid in the sewage system is not sufficient to fulfil a transport function. This results in the aforementioned blockages in the sewage networks. The public can be helped through the provision of alternatives such as dry toilets and mobile toilet trailers as used at festivals and which can be emptied directly into sewage treatment plants.

CONCLUSION 2.3.6

In the field of water supply, electrical energy is required for the transport, treatment and distribution of water. Electrically operated pumps are especially critical for guaranteeing the respective functions. If these stop working, the water cannot be fed through the processing stages and into the distribution system. A natural gradient can only be used for water distribution in a few cases (e.g. the long-distance water supply connecting the Harz Mountains with Leipzig). Water treatment involves energy-intensive processes, some of which may need to be dispensed with in order to save energy during a power blackout. If emergency power generators do not offer the required level of performance, it may be possible to maintain emergency operations restricted to core processes.

Electrically operated pumps are also required for wastewater disposal, both in lifting stations in the sewage system and also in sewage treatment plants for operating the infrastructure. In sewage treatment plants, large quantities of (electrical) energy are required for heating the sewage sludge and for operating the aeration tanks (approximately 50 % of energy consumption).

Most water supply and wastewater disposal processes are becoming increasingly reliant on the use of process, measuring, and control technology, which is also dependent on electricity.

As a result of this major dependence on electricity, a prolonged power blackout would drastically restrict the functions of the water infrastructure.

FOOD SUPPLY 2.4

The »food« sector covers the complex chain from raw materials production through to purchase of the finished products by the end consumer (BLE 2006, p. 3). A power blackout has consequences for the entire food supply sector. However, because of their heterogeneous character, the individual sub-sectors of the food processing industry and the food trade are affected to differing degrees. Moreover, the geographical differentiation and intermeshing of production, processing, distribution and consumption (BBK 2005b, p. 23) and also the rationalisation and decentralisation of warehousing (Prognos 2009, p. 44) create a significant dependence on other sectors such as transport and traffic (Chapter III.2.2) and information technology and telecommunications (Chapter III.2.1).

This chapter will first discuss the structures of the sector (Chapter III.2.4.1) and also the relevant legal bases for disaster management (Chapter III.2.4.2). The consequences of a power blackout for the food supply will then be examined using the examples of agriculture and the food trade. In each case, events during the first few days and the first week will be considered. The analysis of the food trade will further differentiate between the first 2, 2 to 8 and 8 to 24 hours (Chapter III.2.4.3).

STRUCTURES 2.4.1

Agriculture produces foodstuffs and raw materials for further processing by industry; as such, it is the first element in the food supply sector. It is linked with upstream and downstream sectors such as the agricultural engineering, fertilisers and pesticides or food processing industries. It is also often directly dependent on other sectors. For example, many undertakings are dependent on a central water supply and wastewater disposal system. The efficiency of almost all agricultural production processes depends on electricity.

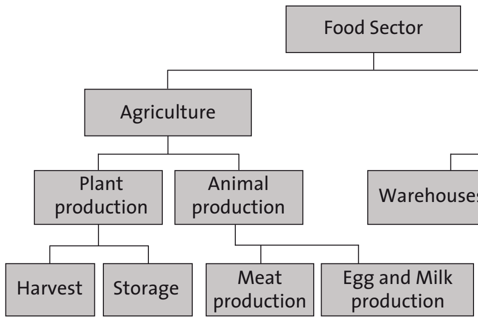
With its broad spectrum of operating forms, the food processing industry processes the agricultural raw materials to create semi-finished and finished products and also ready-to-use products. Production by the food processing industry largely comes to a standstill as a direct consequence of a power blackout. Only a few processing companies have emergency power generators (Prognos 2009, p. 49).[70]

70 However, many mills, for example, obtain some of their electricity requirements from local hydropower plants, thus permitting at least partial operation.

The food trade industry ensures the public is supplied with foodstuffs. Accounting for around 90 % of sales, wholesale chains play a key role within the German food market (food-monitor 2008; LZ website).

The following statements focus on agriculture and the food trade as examples of sub-sectors (Figure 20).

FIGURE 20 STRUCTURES OF THE »FOOD SUPPLY« SECTOR



Own image

AGRICULTURE 2.4.1.1

Germany is a major agricultural producer. Within Germany, Lower Saxony, Bavaria and North Rhine-Westphalia represent important agricultural producers. Areas of key economic focus for German agriculture include the production of milk and grain. Horticulture accounts for 10 % of agricultural sales revenues, although horticultural production accounts for less than 1 % of the useful agricultural area (BMELV 2008b, 2008c; website of destatis a and d; website of eurostat a, b and c; website of Statistik-Portal).

The agricultural production of foodstuffs can be divided into the fields of plant production and livestock production.

PLANT PRODUCTION

Most feed materials and foodstuffs are produced in field crops, although some are produced by horticultural means in the open air and under glass. Plant production is characterised by a one-off harvest, making storage extremely important (BBK 2005b, p. 23; Prognos 2009, p. 46 f.).

The following areas are particularly affected by a power blackout (Prognos 2009, p. 46 f.):

- Harvesting and storage
- Sorting and packing
- Air conditioning and irrigation

LIVESTOCK PRODUCTION

Livestock production can be divided into dairy cattle farming, beef cattle farming, pig farming and poultry farming, and also egg production. These areas are characterised by continuous production (BBK 2005b, p. 23; Prognos 2009, p. 45).

Beef cattle can be kept in outside-climate areas, in uninsulated stalls or in thermally insulated stalls. The cost-effective option of outside climate stalls is the most widely used. The extent to which the different housing forms are used varies regionally. Whereas dairy cattle in the new federal states and in northern Germany are mainly kept in modern freestall barns, most dairy cattle in Bavaria are still kept in stanchion barns. Beef production is mainly based on bull fattening and suckler cow farming. In 2009 farmers kept an average of 71 beef cattle per farm (Brömmer/Deblitz 2005, p. 51; Gesellschaft für Ökologische Tierhaltung e.V. 2003, p. 2 f.; website of destatis c and d; KTBL 2009e; Prognos 2009, p. 46). Calves are kept alone for the first week after they are born, then mainly in groups. They have no special demands in terms of housing and are housed in the same way as fully grown beef cattle (Gesellschaft für Ökologische Tierhaltung e.V. 2003, p. 10; KTBL 2009e).

Pig farming is almost exclusively based on thermally insulated and electrically ventilated sheds. Production forms vary according to group size, namely small groups of 10 to 20 animals, large groups of 20 to 60 animals and large group bays for up to 300 or more animals. In 2009 an average of 398 pigs was kept per farm, although in northern Germany 1,000 animals is the norm, while in southern Germany the figure is around 200 animals (destatis 2009; KTBL 2009b and 2009c). Piglet production is based on housing in large groups. The piglets require special zone heating, which is generally achieved by underfloor heating and heat lamps (Gesellschaft für Ökologische Tierhaltung e.V. 2003, p. 38; KTBL 2009f; Zentner 2006, p. 26)

Poultry farming is based on thermally insulated barns with forced ventilation; the barns are usually heated by means of gas-operated blowers or infra-red lamps. Most poultry farming is based on floor pens. The fattening methods used vary according to the fattening period, which ranges from 32 to 60 days. Most egg production is in cages with small groups of hens, with an increasing proportion based on floor pens and free range systems. In 2007 the average number of animals kept per farm was 15,200 (destatis 2008; Homepage destatis b; KTBL 2009g).

The following areas are affected by a power blackout (Prognos 2009, p. 45):

- Milk extraction (milking systems, refrigeration and cleaning)
- Slurry technology/stall cleaning
- Feeding/grinding and mixing systems
- Lighting
- Air conditioning (heating, cooling and ventilation)
- Sorting systems

According to the Animal Welfare Livestock Husbandry Ordinance (TierSchNutzVO), farms must be equipped with emergency power capabilities if the life and health of animals depend on technical facilities. An emergency power system ensures an adequate supply of feed, light, air, heat and water. The relevant equipment can be designed as stationary devices or as mobile tractive units driven by a tractor. For electrically ventilated barns, the ordinance also prescribes an alarm system to warn of malfunctions.

In addition to feeding systems, the storage of some feed materials also relies on electric power. For example, hay needs to be dried, and concentrated feed needs continuous ventilation as it can only be stored in conditions with a humidity of up to 14 %. If the ventilation stops working, condensation forms and causes the feed to stick together, which makes removal difficult (FEDARENE 2008, p. 9; KTBL 2009b).

Finally, a power blackout jeopardises animals' water supply. In temperatures of around freezing, for example, a cow requires around 50 l of water, a calf 8 l or more, a pig around 20 l, pregnant or lactating sows up to 30 l, a piglet 1 l or more (BayerFarm n.d.; Ewy 2004, p. 49; Kirchhofer 2003; Meyer 2008; Schafzahl 1999).

THE FOOD TRADE INDUSTRY 2.4.1.2

The food trade industry ensures the public is supplied with foodstuffs. The sales infrastructure includes supermarkets, small retailers such as kiosks and petrol stations, specialist shops (e.g. butchers and greengrocers) and weekly markets (Prognos 2009, p. 50). According to a study[71], around half of all branches in the food trade have an independent emergency power supply. These can be used to maintain emergency lighting and in most cases also cash tills and IT systems, while in some cases the refrigeration system can also continue (BMELV 2005, p. 91 f.).

Upstream from the retail trade is a sales infrastructure that is based on a central warehouse or on a regionally organised distribution structure. This acts as an interface between the food processing industry and the food trade industry.

71 The study (BMELV 2005) was based on a survey of eight companies in the food trade industry that accounted for around 50 % of total turnover in the food trade industry in 2002.

Here, there is a general trend towards reducing stocks and/or logistics hubs, leading to a reduction of stocks available to supply the public in the event of a disaster. Moreover, if the electricity supply is interrupted, it is no longer possible to manage and control the flows of goods using mains-powered information technology (BMELV 2005, p. 71 and 98).

STRUCTURE AND REACH OF FOODSTUFFS STORED

According to Rasche et al. (2001, p. 38), the households surveyed keep the following foodstuffs in stock:

Pasta	49.3 %
Sugar	41.8 %
Flour	38.8 %
Rice	38.1 %
Tins/preserves	35.1 %
Vegetables	28.4 %
Fruit	19.4 %
Ready meals	18.0 %
Potatoes	23.9 %
Frozen products (especially meat)	18.7 %
Mineral water	18.0 %
UHT milk	15.7 %
Juices	15.7 %

The range of foodstuffs kept in stock[72] was determined in an unrepresentative survey in five areas of the Münsterland in 2006 (Gardemann/Menski 2008, p. 6 and 10):

> 8 days	5.4 %
6 to 8 days	9.9 %
3 to 5 days	34.7 %
> 2 days	15.6 %
2 days	27.4 %
1 day	6.1 %

Source: Gardemann/Menski 2008, p. 47 f.

The food trade sector's warehouses are equipped with electric industrial trucks and shelf retrieval systems and also electronic information processing and communications technology. If a power blackout occurs, manual operation is only possible to a limited degree because the shelves are often up to 30 m high. The warehouses have uninterruptible power supply, generally via emergency power

72 The BMELV recommends emergency supplies for 14 days (BMELV 2008a).

generators, and in some cases via an autonomous electricity supply. Around 40 % of warehouses can maintain full operations including freezer/chiller storage or can at least maintain their IT systems and restricted warehouse operations. With regard to the length of time for which emergency power supplies in warehouses can last, survey responses varied from »2 hours« to »permanently«; the average length quoted was around 34 hours (BMELV 2005, p. 70 and 102).

When considering the overall situation concerning the food supply in a disaster situation, stocks kept by households also play an important role. A representative study examined the level of stocks kept in households, i.e. the stocking of foodstuffs that are not intended for daily/immediate consumption and that do not have to be replaced on a regular basis. According to this study, 71.6 % of households maintain stocks; 15.7 % stated they do not keep any foodstuffs in stock (Rasche et al. 2001, p. 36).

In the event of a power blackout, however, the foodstuffs kept in stock must be considered against the backdrop of the (limited) possibilities available for their preparation.

LEGAL BASES 2.4.2

Critical situations in the food sector are essentially regulated through two laws at federal level that are designed to ensure the supply of foodstuffs. In this context, it is important to differentiate between the regulations governing a state of tension and a state of defence as covered by the Emergency Food Control Act[73] (ESG) and other supply crises as covered by the Emergency Food Supply Act[74] (EVG). In Section 1 [2], the Emergency Food Supply Act (EVG) defines a supply crisis as a situation where there is a serious threat to the ability to cover demand for essential food and agricultural products in large parts of the federal territory and this threat cannot be removed at all, cannot be removed on time or can only be removed with unreasonable means. According to the Emergency Food Supply Act (EVG), the existence of a supply crisis is decided by the Federal Government (by means of a statutory instrument). Under the Emergency Food Control Act (ESG) and the Emergency Food Supply Act (EVG), statutory instruments can be used to issue provisions governing, for example, the manufacture, processing, delivery and allocation of foodstuffs, their control in terms of time and geography; they can also be used to set prices of foodstuffs and to prohibit their com-

73 Act on Ensuring the Supply of Products of the Food and Agricultural Sector and of the Forestry and Timber Industry (Emergency Food Control Act) (ESG). In the version pronounced on 27 August 1990. Last amended by Section 182 of the Ninth Ordinance on the Adaptation of Responsibilities dated 31 October 2006 (BGBl. I, p. 2407).

74 Emergency Food Supply Act of 20 August 1990 (BGBl. I, p. 1766), last amended by Section 186 of the ordinance of 31 October 2006 (BGBl. I, p. 2407).

mercial sale (BBK 2008a, p. 22; BLE 2006, p. 3).[75] In addition, the Traffic Services Act (VerkLG)[76] permits the requisitioning of transport services or means of transport for the purpose of transporting goods.

The most important provisions governing the keeping of farm animals are set forth in the Animal Welfare Livestock Husbandry Ordinance (TierSchNutz VO)[77]. In addition to general requirements for animal husbandry, the ordinance also includes structural provisions designed to ensure provision for animals is always adequate.

The Ordinance Concerning the Protection of Animals in Connection with Slaughtering[78] (TierSchlV) is also of importance for the production of animal products as it regulates the anaesthetisation and slaughter of animals from the point of view of avoiding agitation, pain, suffering and harm. The law on foodstuffs focuses on ensuring hygiene. However, there are general clauses dealing with operators' obligations to safeguard critical production areas.

CONSEQUENCES 2.4.3

The following section considers the effects of a power blackout during the winter, because seasonal weather conditions are a decisive factor in determining the degree to which the food sector is affected.[79]

AGRICULTURE 2.4.3.1

0 TO 24 HOURS

Hardly any damage is caused within agricultural production during the first 24 hours. The winter represents a rest period for tilling and open-field production, so there is no damage to fields. With horticultural production under glass, however, air conditioning and irrigation systems stop working. Storage facility ventilation systems that are designed to cool, heat and remove moisture from the

75 Section 2 [1] of the Emergency Food Supply Act (EVG)

76 Traffic Services Act dated 23 July 2004 (BGBl. I, p. 1865), amended by Section 304 of the ordinance of 31 October 2006 (BGBl. I, p. 2407)

77 Animal Welfare Livestock Husbandry Ordinance in the version promulgated on 22 August 2006 (BGBl. I, p. 2043), amended by the ordinance of 1 October 2009 (BGBl. I, p. 3223)

78 Ordinance Concerning the Protection of Animals in Connection with Slaughtering dated 3 March 1997 (BGBl. I, p. 405), amended by Section 19 of the law of 13 April 2006 (BGBl. I, p. 855)

79 With regard to the damage arising, the regions affected by a power blackout are of relevance for a comprehensive vulnerability analysis. For example, damage would be particularly severe if the »north-west belt« was affected; this area stretches from Schleswig-Holstein and across Lower Saxony to North Rhine-Westphalia and has the highest density of cattle stocks.

stored goods are also affected (website of Gut Derenburg; Prognos 2009, p. 46 f.). However, production and storage facilities are able to ward off external influences such as sharp temperature fluctuations for a certain time, thus preventing major losses of production.

In animal production, emergency power generators safeguard all supply systems necessary to the survival and health of the animals. However, additional functional areas may be affected, depending on the sector of production and on the available emergency power capacity. This includes the cleaning of stalls, which is implemented using different technical means. In beef farming, electric scrapers are mainly used; however, the slatted floors used in pig farming and the manure pits mainly used in poultry farming do not generally rely on electricity. With poultry farming for meat production, cleaning and disinfection of the housing is only required between two fattening cycles (Website of IKL a and b; website of KTBL; KTBL 2009d, 2009f and 2009g; Pöllinger 2001, p. 35 and 38 f.; Prognos 2009, p. 45).

With dairy cattle farming in particular, milking systems and milk storage can be affected, depending on the performance capacity of the emergency power generator. With cows, a missed milking session or postponement of the milking time by several hours can lead to udder infections and ultimately to death. Switching to hand milking is out of the question as this requires a lot of practice and strength. The animals thus have to be dried out (Schweizer Milchproduzenten n.d.; Prognos 2009, p. 45; Steetskamp/Wijk 1994, p. 12).

Thanks to the emergency power supply, no disruptions are encountered with pig and poultry farming for meat production or with egg production.

24 HOURS TO 1 WEEK

After 24 hours the fuel supplies for the emergency power generators and of the agricultural machinery on the farms are exhausted. Operations can only be maintained where fuel supplies are available or can be organised.

Where production is under glass, the effects of the cold and a lack of irrigation lead to a progressive decline in quality and even to a loss in production. The falling temperature also affects foodstuffs that are in storage. There is a reduction in the quality and shelf life of stored goods such as potatoes that are sensitive to the cold. In addition, failed ventilation systems and cooling external walls favour the formation of condensation. As a result, even goods such as grain that aren't sensitive to the cold suffer damage in terms of their quality and shelf life (Maiwald 2005; Prognos 2009, p. 47). In animal husbandry, lighting, ventilation, heating and feeding systems stop working. Depending on the type of farming, the animals react in different ways to the restricted supplies. In some circumstances, for example, they may compensate for problems through physical properties or social behaviour.

Lighting, ventilation and heating

The failure of lighting systems makes numerous work processes more difficult (e.g. monitoring the condition of the animals). It also has a negative effect on the welfare, health and performance of animals (Prognos 2009, p. 45). The disruption to the power supply causes ventilation systems to stop working, and fresh air is fed through ventilation flaps that are opened either automatically or manually. The inflow of unheated external air causes the temperature in the sheds to fall sharply. In addition, the lack of through ventilation causes permitted pollutant concentration thresholds to be exceeded[80]; this reduces the animals' performance and increases their propensity to disease (website of HBLFA b; SKOV 2008).

The loss of heating has different consequences depending on the type of animal and housing system. Beef cattle have a higher tolerance to cold (even high-performance breeds). Provided they have a thermally insulated bedding area, they do not suffer any damage to health, even in extremely cold temperatures (up to -30 °C) (Kramer 2001, p. 29; KTBL 2009e; Zähner 2004). Calves are similarly resilient (KTNL 2009e). Although they should not be exposed to temperatures below 10 °C (up to 10 days after their birth) or 5 °C in the first few days of their life, ensuring protection against the elements and re-housing to form groups of calves initially prove adequate measures to prevent major losses.

Pigs are also able to withstand the reduced temperatures (MLR, n.d.). Piglets, on the other hand, are more susceptible to cold. Although they can be kept in outside conditions, special structural measures are required (KTBL 2009f). Since such measures are not part of customary farming methods, the death of the youngest animals in particular is unavoidable.

Poultry stocks are also able to survive the drop in temperature. However, their growth and laying rates are significantly reduced. By contrast, chickens require constant temperatures of between 20 and 35 °C and perish within a few minutes. Hatcheries also suffer a total loss within a matter of minutes because the high temperatures required for the eggs can no longer be guaranteed.

Feeding

The supply of animal feed using partially or fully automatic mixing and conveyor systems also runs into problems. The required quantities of feed cannot be prepared and distributed by hand. From a physical point of view, fully grown

80 The Animal Welfare Livestock Husbandry Ordinance (TierSchNutzVO) specifies threshold values for ammonia, carbon dioxide and hydrogen sulphide.

animals (beef cattle, pigs and poultry) can generally withstand the restrictions created by the failure of the emergency power supply. However, the situation produces a significant increase in stress levels for the animals and there is a sharp rise in behaviour patterns such as feather pecking, biting other animals or cannibalism. Possible triggers for this include a lack of light intensity and quality (e.g. colour spectrum), increased pollutant gas concentrations and draughts or short-term temperature fluctuations (website of HBLFA a; KTBL 2009a). Since all these factors combine during a power blackout, changes in behaviour are likely to be even more pronounced. This creates further threats for animal stocks and also hygiene problems (e.g. through injured and dead animals).

Another problem is that of supplying the animals with drinking water, especially from public pipeline networks. The supply of water stops in places where pumps have failed and can no longer be operated. A switch to a manual water supply in stalls is possible in principle because the animals' warmth creates a microclimate and frequent drinking prevents the water that is provided from freezing. However, even if a well is available, it is unlikely that large farms would be able to ensure an adequate supply of water for all animals.

The longer the power blackout lasts the greater the problems encountered in looking after the herds; in some cases, it is no longer possible to ensure adequate provision at all. Almost no water is supplied via public water system pipes. In many cases, mould formation renders stocks of feed unusable. Outbreaks of disease (e.g. respiratory) threaten the existence of entire farms.

Overall – and especially in large pig and poultry farms – there are likely to be mass mortalities of animals (Reichenbach et al. 2008, p. 25).

THE FOOD TRADE INDUSTRY 2.4.3.2

0 TO 24 HOURS

Within the first 2 hours, branches without emergency generators turn away new customers because lighting, cash tills and billing systems (and the associated merchandise management), refrigeration units, security systems and doors stop working (Prognos 2009, p. 50). Branches with an emergency power supply can continue to operate without major restrictions, although refrigeration units may stop working. Most people try to postpone their shopping until the power supply is restored. Distribution centres where the emergency power supply is unable to maintain all functions experience a sharp fall in product-handling performance (BMELV 2005, p. 70). Moreover, the traffic situation causes delays in the distribution process.

During the period between 2 and 8 hours, people start to consider the possibility of a blackout lasting several days. Branches without an emergency power generator thus start up temporary operations. Initially, this requires a switch to manual cash tills and subsequently to manual inventory management and re-ordering (BMELV 2005, p. 70). As the lighting is no longer working, the cash till area has to be lit using torches or similar devices and used as a sales counter where the staff hand over goods to customers. Also, and depending on the opening time remaining, special offers on frozen products are considered as these will become unsaleable overnight. Since the fuel supplies of most emergency generators are used up during this period, other branches start to make similar arrangements.

In the period between 8 and 24 hours, food trade outlets reduce their opening times according to the available daylight. The emergency power supply stops working in other warehouses. Companies' emergency plans for such situations are not designed for widespread crises. They are generally geared to a power blackout affecting a few warehouses within a region or to the loss of a single warehouse. Due to the breakdown in communications and the general problems encountered in other sectors, the planned measures such as shift work using a two or three-shift system at remaining locations or approval of Sunday working and Sunday lorry journeys can only be implemented to a limited degree (BMELV 2005, p. 70 and 95 f.).

24 HOURS TO 1 WEEK

During the first week there is an increasing change in consumer behaviour because the power blackout restricts customary mains-based cooking habits. Hot meals can only be prepared using camping stoves, gas cookers, barbecues or fireplaces (Gardemann/Menski 2008, p. 50). Consequently, the main products purchased are ready-to-eat foodstuffs such as bread and bakery products, sausage products, cereals and fruit and also tinned products (BMELV 2005, p. 71), basic foodstuffs such as milk, oil, sugar and water, and also items such as blankets, torches, batteries and candles. These products are sold out in many locations due to the increased demand, which is fuelled by intensive stockpiling purchases at the latest once the duration of the power blackout becomes known.

Very few food shops have sizeable storage capacities. Supplies can only be replenished on a sporadic basis as product handling in warehouses is restricted and fuel for delivery vehicles is in short supply. Shelves thus empty within 2 to 5 days (Prognos 2009, p. 50). Despite the refrigeration chain having been interrupted, some food is sold or enters circulation as a result of thefts or due to it being given away later on during the blackout. This harbours increased risks to health (Prognos 2009, p. 50 f.) If the region does not receive any further supplies, stocks in shops and households are likely to be used up by the end of the first week.

By contrast, warehouse stocks are considerably bigger and are available, provided an emergency power supply for freezers exists or can be established. Without effective refrigeration the required temperatures can only be maintained for around 24 hours (BMELV 2005, p. 70).

STORAGE RANGE FOR WAREHOUSE STOCKS BASED ON A NORMAL FLOW OF GOODS (IN DAYS)

› Frozen products	10 to 50, average 22
› Refrigerated products	1 to 10, average 5
› Fresh products	0 to 10, average 4
› Other	7.5 to 30, average 18

BMELV 2005, p. 95

As the emergency power supply can't be maintained across the board, all warehouses within the area affected by the power blackout generally cease operations during the first 2 days.

The increased demand makes the food trade industry the »weakest link« in the supply chain. Since data lines and IT have stopped working, it is no longer possible for head offices, warehouses and branches to communicate with each other about stock levels and demand. Due to the lack of supplies for the public, the authorities consider making stocks of food available and mobilising reserves kept for crisis situations (BMELV 2005, p. 119 f.). Nevertheless, people in positions of responsibility still expect drastic supply bottlenecks for key staple foods and also for special product areas such as baby food. As reports are received of increased deaths in nursing homes and sporadic disputes over food, the authorities become aware of the possibility of risks to public order resulting from outbreaks of local unrest.

CONCLUSION 2.4.4

The developments described highlight the successive build-up of problems for the »food supply« sector following a prolonged power blackout. The significant damage to stored goods and to animal stocks in agriculture, the extensive collapse of the food processing industry and the inability of retail structures to provide adequate supplies for large sections of the population mean the sector's ability to function within the region is reduced to a minimum. Due to the generally low level of stocks held by private households, serious food supply bottlenecks emerge as early as the end of the first week.

Less central regions in particular have inadequate supplies. In the few branches that remain open, disputes break out over food deliveries, food ration handouts or scarce foods; in some cases there are serious, often physical, altercations that can't always be resolved by the law enforcement agencies. The situation causes particular suffering for people such as the elderly, the sick or small children who have limited capabilities in terms of taking action or who rely on special foodstuffs. Finally, problems are encountered in ensuring supplies for the local forces deployed, especially those from nearby regions.

Stabilising food supplies and ensuring their fair distribution among the public become a priority for the authorities. The survival of large numbers of people and also the maintenance and safeguarding of public order depends on these authorities' ability to successfully manage this task.

HEALTH CARE SYSTEM 2.5

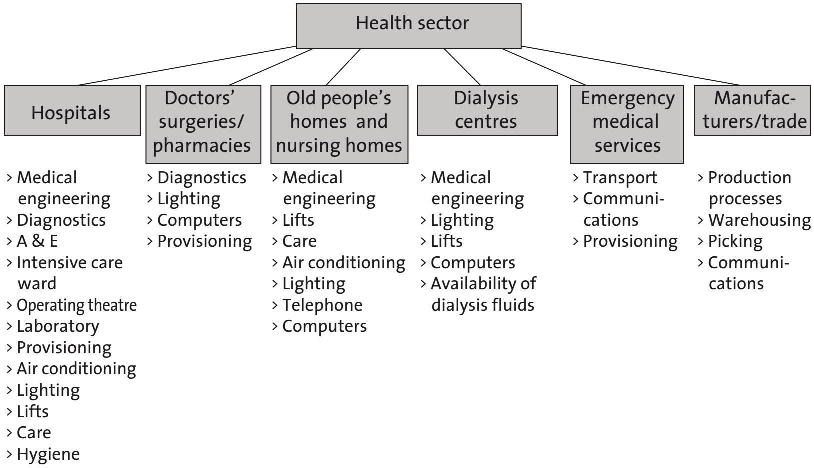
The most important function of the health care sector is to provide medical and pharmaceutical supplies for the population. The sector is organised on a decentralised basis with a strong emphasis on the division of labour.

This Chapter starts with an outline of structures (Chapter III.2.5.1) of the health sector and of the sector-specific legal bases for disaster management (Chapter III.2.5.2). Subsequently, the chapter considers the consequences of a power blackout as experienced in hospitals, doctors' surgeries, pharmacies, dialysis centres and nursing homes, by emergency medical services and by manufacturers and retailers of pharmaceutical products. In a first step (Chapter III.2.5.3.), the consequences are categorised according to the length of time (the first 2 hours, 2 to 8 hours and 8 to 24 hours) since the onset of the power blackout. A second step (Chapter III.2.5.4) discusses possible later consequences occurring from the second day to the end of the first week. This is followed by a conclusion (Chapter III.2.5.5).

STRUCTURES 2.5.1

The key players (Figure 21) include, among others, over 2,000 hospitals with around 21,000 intensive-care beds, 1,200 dialysis centres, around 11,000 nursing homes, 21,500 public pharmacies (plus 470 hospital pharmacies) and at least the specialist physician sections of more than 100,000 doctors' surgeries (BBK 2008b; Bundesärztekammer 2006; Frei/Schober-Halstenberg 2008, p. 7; DKG 2009; Wieler et al. 2008, p. 1). Almost all establishments involved in supplying medical and pharmaceutical products/services to the public rely directly on the supply of electricity.

FIGURE 21 SELECTED BASIC STRUCTURES AND COMPONENTS IN THE HEALTH SECTOR



Own image

LEGAL BASES 2.5.2

LAWS AT THE LEVEL OF THE LÄNDER

The federal Länder are responsible for legislation governing peacetime disaster control, the emergency medical services and public health services; they are also responsible for the law relating to hospitals, taking into account the competing legislation of the Federal Government. The (fire and) disaster control laws of the federal Länder often contain regulations that refer specifically to players within the health sector.

Their cooperation and participation during peacetime disaster control is also regulated in the hospital laws of the Länder. In some federal Länder, these laws (as also in Section 21 [4] No. 1 of the Civil Protection and Disaster Management Law of the Federal Government (ZSKG) in a state of defence) establish an obligation on hospital operators to draw up alarm and operations plans along with corresponding exercises to ensure the provision of medical care (e.g. StMI 2006). Another important aim is the expansion of treatment and reception capacities in the event of a major damage situation or a disaster (Paul/Ufer 2009, p. 148).

Hospitals are obliged to cooperate with, among others, registered doctors, emergency medical services and disaster control authorities.[81]

The ordinances of the Länder that set out requirements for hospital buildings include various protection requirements (e.g. for electrical systems or for emergency power supplies) (BSI 2005, p. 133).

The Land laws on emergency medical services (or laws on emergency medical services) regulate pre-clinical care for medical emergencies below the disaster threshold (Paul/Ufer 2009, p. 134) and therefore also the management of major damage situations.[82] The emergency medical services and the hospitals are accorded particular importance. Most public emergency medical services are operated by the counties and free cities. The operators are obliged to organise emergency medical services on an area-wide basis and in accordance with requirements. Emergency medical services are provided either by the municipal operators with their fire brigades or by agents commissioned by them (especially the major aid organisations).

Finally, it is important to mention the laws on the public health service that deal with its inclusion in disaster control (although not on a uniform basis and somewhat inadequately) (Paul/Ufer 2009, p. 132).

FEDERAL LAWS

Under the Civil Protection Amendment Act of 2 April 2009, Section 12 of the Civil Protection and Disaster Management Law of the Federal Government (ZSKG) specifies, on a nationwide basis, that the Federation's civil protection capacities are also available to the Länder to help them accomplish their tasks in the field of disaster control. According to Section 13 [1] of the Civil Protection and Disaster Management Law of the Federal Government (ZSKG), the Federation augments the disaster control capacities of the Länder in several areas, including medical services and care (dual benefit concept for civil protection). This includes, for example, the additional provision of medical equipment pursuant to Section 23 of the Civil Protection and Disaster Management Law of the Federal Government (ZSKG), which allows the Länder to plan accordingly.

Assistance within the context of »civil-military cooperation« involving the use of medical equipment of the Federal Armed Forces is also possible as a subsidiary task of the Federal Armed Forces. This requires an official request for assistance from the competent authority.

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81 Not all disaster control laws of the Länder contain rules on the participation of pharmacies in disaster control and even if they do, this is to very varying degrees. This concerns, among others, functions and duties in connection with alarm and operations plans (Paul/Ufer 2009, p. 176).

82 According to the official interpretation, a major damage situation exists within the emergency medical services if supply requirements are above normal provisions.

The Pharmacies Act (ApoG) obliges pharmacies to ensure adequate supplies of pharmaceuticals for the population in the public interest (Section 1 [1] of the Pharmacies Act (ApoG)). Other provisions of the Act and also the provisions of the Ordinance on the Operation of Pharmacies (Apo BetrO) define the necessary requirements for this. For example, the Ordinance on the Operation of Pharmacies (Apo BetrO) regulates the minimum stocks to be held by public and hospital pharmacies and also the provision of pharmaceuticals to the emergency medical services (Paul/Ufer 2009, p. 168 ff.). Hospital pharmacies must keep stocks of drugs that equate to at least the average demand over a 2-week period.

The Pharmaceuticals Act (AMG) contains strict regulations for the licensing, manufacture, purchase and sale of pharmaceuticals in the interests of protecting consumers. Derogations are stipulated to cover special emergencies and threat situations (e.g. epidemics). Section 47 [1] No. 5 of the Pharmaceuticals Act (AMG) stipulates that as an exception to the pharmacy monopoly, pharmaceuticals may also be sold to central pharmaceuticals procurement centres to cover own requirements of authorities, organisations and companies.

Finally, it is also important to mention the Narcotics Law (and the Ordinance Concerning Foreign Trade in Narcotics) and also medical device legislation (and especially the exemptions contained in Section 44).

GUIDELINES

The BBK (2007) has issued guidelines for the health sector aimed at reducing the vulnerability of disaster control and assistance organisations. Under these guidelines, control measures in relevant areas can be verified by means of a checklist. Among the guidelines geared towards a power blackout and individual establishments (e.g. BBK 2006), it is important to mention a publication by the BBK on risk and crisis management in hospitals (BBK 2008b).

DIRECT CONSEQUENCES 2.5.3

Even immediately after the power blackout, there are increased numbers of injuries and fatalities due to accidents; the number of injuries and fatalities is increased due to restricted medical rescue and transport capabilities (Prognos 2009, p. 57, 73 and 75). Hospitals, old people's homes and nursing homes in particular have large numbers of people in a critical condition who cannot tolerate a deterioration in treatment conditions.

HOSPITALS 2.5.3.1

According to DIN-VDE guideline 0100-710, hospitals have an emergency power supply that maintains essential systems in core operational areas for 24 hours. Corresponding requirements are also stipulated in the hospitals legislation of the individual federal Länder, in special ordinances or in individual decisions relating to building law (Geier et al. 2009, p. 76). Fuel supplies must be designed to last for 1 or 2 days, but can last a little longer with correspondingly lower loads. According to a study by Prognos (2009, p. 72 f.), the emergency power generators that are installed generate 5 to 10 % of a hospital's average power requirements (BBK 2008b, p. 77). This allows the following equipment to be operated:

> Emergency operating theatres including ventilation
> Life-supporting medical systems on intensive-care wards (e.g. ventilators)
> Refrigeration of blood supplies and organs
> Heating and water pumps
> Emergency lighting
> Patient transport lifts
> Ventilation in sensitive areas
> Sterilisation (Prognos 2009, p. 72)

By contrast, areas and equipment that are not directly required for the treatment of sick and injured persons are not supplied with electricity:

> Administration, data centre
> Physiotherapy, etc.
> Canteen
> General hot water supply
> Large items of diagnostic equipment such as MRI and CT scanners (Prognos 2009, p. 73).

In the first 2 hours following the power blackout the main disruptions are of an organisational nature. Processes are delayed due to the failure of information and communications systems, because administrative computers no longer work and because patient files can't be processed. In the medical field, some areas of diagnostics are affected and apparatus-based diagnoses in particular can no longer be made or can only be made on a restricted basis (Prognos 2009, p. 74).

In addition, the consequences of the blackout in other sectors of society affect operations within hospitals. For example, an increase in injuries typically associated with road accidents can be expected, especially if the power blackout occurs in the evening. There may also be injuries caused by chemicals leaking from industrial processes that can no longer be controlled (Steetskamp/Wijk 1994, p. 12).

More accident victims can be expected in the period from 2 to 8 hours after the power blackout strikes. Endeavours are therefore made to mobilise additional personnel to care for new admissions and to look after patients who are unsure or who need assistance. This proves problematic because of the restricted availability of telephones. As the blackout continues, the loss of office activities for all work processes becomes a problem (Steetskamp/Wijk 1994, p. 59) because patient data, etc. can't be viewed and forwarded. The increase in external calls received starts to cause a serious problem in terms of overload on telephone switchboards (Prezant et al. 2005). Correct storage of pharmaceuticals and medical products is jeopardised if adequate refrigeration can't be ensured. Due to the fact that the canteen is no longer operational and also to the delivery problems caused by the traffic situation, hot meals must be at least partially replaced by cold food. Potable water becomes scarce.

In the period from 8 to 24 hours after the power blackout strikes, the disruptions to medical care increase significantly and extensive organisational measures must be taken to mitigate the consequences. As the extent of damage has now been roughly ascertained and the expected duration of the blackout has been communicated to the public, alarm and emergency plans are put in place. These generally provide for the discharge of as many patients as possible (e.g. those with minor injuries and convalescents). The establishment of »emergency hospitals«[83] is also considered. Due to the restricted heating and lighting capacities, the patients who remain are concentrated together and additional blankets are distributed. An alternative roster must also be implemented and staff must live in at the hospital where necessary. Administrative activities such as maintaining patient records have to be carried out manually (Göbel et al. 2008, p. 24; Prognos 2009, p. 9, 73 f.; Steetskamp/Wijk 1994, p. 19 and 59).

As the traffic situation gradually eases, the number of accident victims attending hospitals declines. On the other hand, people freed from lifts, traffic jams or trains are admitted suffering from symptoms of dehydration, debilitation and hypothermia. Many people who receive medical care at home are brought to hospitals by relatives or care services. The number of self-admissions increases (Prognos 2009, p. 58; Steetskamp/Wijk 1994, p. 12); in some cases this is because domestic emergency call systems and medical equipment used at home are no longer working (Stahlhut 2010, p. 19).

It is no longer possible to guarantee the supply of hot meals to patients. In a few hospitals ready-prepared foods can still be supplied by delivery services. There is a risk that the disruption to nutrition will have a detrimental impact on the healing process and that the availability of special nutrition for diabetics, dialysis patients and others will become a problem (Hye 2000, p. 24).

DOCTORS' SURGERIES 2.5.3.2

Most doctors' surgeries do not have any emergency power capacities and it is also rare for medical centres to have such capacities. General medical practices

83 The last auxiliary hospital in the Federal Republic was taken out of service in 2007 after the auxiliary hospitals were gradually removed from the obligation in the 1990s (Peters 2009,p. 22).

can maintain only rudimentary operations without electricity because many diagnoses can be made without using mains-dependent equipment. By contrast, specialist doctors' surgeries rely on specialist technology and cannot therefore operate without electricity (Prognos 2009, p. 74).

During the first 2 hours after the power blackout doctors can continue to provide treatment for minor cases. Patients whose diagnosis and treatment requires the use of equipment or very good lighting conditions must be turned away or sent to a hospital. Some patients with appointments postpone their visits due to the power blackout or on account of the major traffic problems. In many practices doctors will endeavour to care for their patients in the best possible way, even if they can no longer access certain diagnostics equipment or their electronic patient and information data records.

If the power blackout occurs in winter, doctors' surgeries must close in the period from 8 to 24 hours after the power blackout because of the effects of the cold. The mobilisation of registered doctors to assist with hospital care (e.g. in accordance with the respective Land disaster control laws[84]) is therefore considered. Doctors can for example be deployed in reception centres that are set up or used to support the emergency medical services in an attempt to maintain decentralised medical care (Steetskamp/Wijk 1994, p. 20).

PHARMACIES 2.5.3.3

Most public pharmacies have no emergency power capacities (Prognos 2009, p. 74). In the first 2 hours after the power blackout, operations are therefore hampered because lighting and cash systems do not work. If pharmacies have automatic inventory systems, drugs and other products that are delivered must be placed into stock and checked out by staff. Electronic ordering systems can no longer be used.

Fewer customers visit pharmacies in the period up to 8 hours after the blackout. In addition, the lack of lighting/makeshift lighting means pharmacies' opening times are restricted to daylight hours.

Within a period of up to 24 hours after the power blackout, medications that require refrigeration and that have to be stored at between 2 and 8 °C become unusable. Customers must therefore be referred to hospitals for the issue of such medications (Steetskamp/Wijk 1994, p. 59). The first pharmacies announce that they will close.

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84 For example, in Baden-Württemberg, Section 5 [3] of the Disaster Control Act dated 22 November 1999 (GBl. p. 625), last amended by Section 3 of the law of 7 March 2006.

DIALYSIS CENTRES 2.5.3.4

Most dialysis centres are not located in hospitals and are therefore not subject to their requirements in terms of building and safety engineering. Hieter et al. (2010) assume that most dialysis centres do not have emergency power supplies.

Around 60,000 to 80,000 people in Germany rely on dialysis. Essentially, there are two types of dialysis – haemodialysis and peritoneal dialysis. Both methods require large quantities of dialysis fluid that cannot be allowed to freeze. For haemodialysis (around 95 % of patients) up to 27 l are required per week and per patient, while for peritoneal dialysis the figure is up to 87.5 l per week and per patient. Due to the required space and the nursing care required, the vast majority of haemodialysis patients undergo dialysis in dialysis centres. In addition, dialysis centres forward orders for peritoneal dialysis patients (who depending on capacity store their dialysis fluid at home) to suppliers or central warehouses (Baxter 2009; Breuch 2003, p. 247; Toepfer n.d. a and n.d. b; website of open drug database; website of Roche; Wieler et al. 2008, p. 2; LIGA.NRW 2005, p. 1).

The treatment of haemodialysis patients is impaired in the first 2 hours after the power blackout. Although modern dialysis equipment is fitted with batteries that maintain key functions for a certain time, older equipment may not have such batteries and treatment has to be interrupted (Breuch/Servos 2006, p. 209 f.). In the period from 2 to 8 hours after the blackout even newer equipment stops working and medical care in dialysis centres gradually comes to a halt.

In the period up to 24 hours after the power blackout it therefore becomes necessary to take measures to ensure further treatment of patients and avoid panic. A start is made on transferring patients, equipment and dialysis products to hospitals or to reception centres, provided sterile conditions can be established at such centres.

OLD PEOPLE'S HOMES AND NURSING HOMES 2.5.3.5

Some old people's homes and nursing homes have an emergency power supply (in accordance with hospital regulations specific to the federal states) that is capable of lasting a few hours.[85] In the period of time up to 2 hours after the power blackout, staff endeavour to respond to the loss of electrical equipment. For example, oxygen concentrators are replaced by pressurised gas cylinders where possible. Further problems arise due to the failure of facilities such as lifts, door

85 For Baden-Württemberg it was established that »only around one-third of old people's homes and nursing homes have an emergency power supply« (Hiete et al. 2010, F 10).

access systems and emergency communications and also as a result of possible staff shortages (Prognos 2009, p. 75).

Over the next 6 hours there is little change in the situation, provided the emergency power generators have enough fuel. If the generator is not sufficiently powerful to ensure the kitchen can continue operations, disruptions are encountered with the supply of food. If the emergency power generator can't be replenished with fuel or if there is no autonomous power supply, the emergency lighting, hot water supply, general air conditioning and refrigeration for the morgue all stop working. In the winter, the temperature in internal rooms will fall relatively quickly if no heating is available. Depending on the situation, medical treatments must be interrupted and it becomes necessary to transfer at least some of the patients (Steetskamp/Wijk 1994, p. 59; ZVEI n.d.).

EMERGENCY MEDICAL SERVICES 2.5.3.6

The emergency medical services[86] work in accordance with the Länder laws on disaster control and the laws on emergency medical services[87] in providing first aid and transporting sick and injured persons; they also rescue and free people, repair or replace broken-down infrastructures and clear obstacles. The operations control centres are equipped with emergency power generators to ensure an uninterruptible power supply. The equipment required for operations is supplied with power via the vehicle wiring systems or through batteries (website of Freiwillige Feuerwehr Schwandorf; website of THW a, b).

The number of accidents increases in the first 2 hours following the power blackout (Chapter III.3). At the same time, the capacities for making emergency calls are heavily restricted as communications infrastructures break down or become overloaded. After a while and once it appears that the power blackout will last for some time, there is an increase in traffic from workplaces. This hampers the ambulances, which need significantly more time to complete their missions (Prognos 2009, p. 57 f. and 81).

The traffic situation eases a little in the time between 2 and 8 hours. Emergency services and emergency medical services can now use transport routes better

86 For medical care in particular: Workers' Samaritan Federation [Arbeiter-Samariter-Bund] (ASB), German Lifeguard Association [Deutsche Lebens-Rettungs-Gesellschaft] (DLRG), German Red Cross [Deutsches Rotes Kreuz] (DRK), St. John Accident Assistance [Johanniter-Unfall-Hilfe e.V.] (JUH), fire service, Maltese Cross Relief Service [Malteser Hilfsdienst] (MHD). The use of these aid organisations in disaster control is regulated in the disaster control laws of the Länder; the Act on the Regulation of the Legal Relationships of Volunteers of the German Federal Agency for Technical Relief applies to the Federal Agency for Technical Relief (THW).

87 For example, in North Rhine-Westphalia the Emergency Medical Services Act in the version dated 16 July 1998 (GBl. 1998, p. 437), last amended by the law of 10 November 2009 (GBI. p. 643).

(Prognos 2009, p. 58). Most operations involve the provision of care and clearing long traffic jams, and also freeing people from lifts and trains (Steetskamp/Wijk 1994, p. 12). Radio communication encounters increasing problems as the BOS radio system gradually stops working (Chapter III.2). The batteries for the medical equipment in the ambulances (for electrocardiograms or defibrilation) have to be charged at headquarters – provided their emergency generators are working.

MANUFACTURERS AND TRADE 2.5.3.7

The availability of pharmaceutical products is of crucial importance for medical care. The following are required:

- the correct drugs
- in the correct quantity
- at the correct time
- in the correct place
- for the correct recipient (Ackermann et al. 2009b, p. 468).

The pharmaceuticals industry produces drugs in accordance with demand. Medicines are either sold directly by manufacturers to hospitals and pharmacies or are sold via the wholesale pharmaceuticals trade.[88] The wholesale pharmaceuticals trade also performs a warehousing function. This is to enable production delays within the industry to be balanced out and to cover any peak demand for medicines. Moreover, stockholding by pharmacies is now optimised to such an extent that instead of storing medicines, pharmacies receive deliveries from wholesalers several times a day, with wholesalers now playing an increasingly decentralised warehousing role (website of PHAGRO e.V., a, b and c).

The power blackout has a direct impact on the production of drugs, which even if emergency power capacities are installed at several locations, cannot be maintained at adequate levels in order to safeguard segments of production and the provision of critical and production-related processes. Moreover, the storage of fuel supplies on site may be restricted on operational grounds. The wholesale pharmaceuticals trade is also affected to a considerable extent. Many aspects of warehousing and associated activities such as sorting, transporting or packaging require the use of electricity. Moreover, ensuring a flow of goods that is in line with requirements relies on functioning communication between traders and pharmacies along with an intact sales infrastructure.

Pharmaceuticals production comes to a halt within the first 2 hours of the power blackout. The wholesale pharmaceuticals trade is also badly affected. For exam-

88 The loss of production, communications (e.g. the Internet) and postal services would affect direct dispatch to end consumers to such an extent that it is unlikely it would be able to continue functioning.

ple, automated picking systems stop working, meaning pharmaceutical products can now only be picked by manual means. However, this is considerably hampered because lighting and data processing systems have stopped working. Processing incoming and outgoing deliveries of goods is therefore much more time-consuming. This creates delays within sales, and these are exacerbated by the transport situation.

In the time period up to 8 hours after the power blackout, production operations and also operations within the warehouses come to a total standstill. Some employees leave their workplace during this phase. The failure of communications systems means orders can now only be submitted via suppliers.

Around 24 hours after the power blackout it is no longer possible to guarantee the sale of pharmaceutical products differentiated on the basis of time, local area and requirements. No further orders can be accepted, goods can't be processed accordingly and can't be delivered due to the increasingly dwindling supplies of fuel for vehicles. Moreover, temperature-sensitive products perish at manufacturers and in warehouses.

FURTHER CONSEQUENCES – A LOOK AT WEEK 1 2.5.4

After just 24 hours, it can be seen that the loss of the power supply places considerable strains on medical care, which is based on the division of labour and which has a decentralised structure. Problems at individual facilities are increasingly compounded and increasingly impair the sector's role of supplying the population with medical and pharmaceutical services.

In addition, the increasingly apparent consequences of the blackout in other sectors of society have a growing impact on the supply of medical services and products:

- The food supply sector suffers breakdowns in production, in trade and in transport (Steetskamp/Wijk 1994, p. 58 ff.). If the power blackout lasts for several days the supply chain in the affected area suffers a virtual total collapse. A disruption in the supply of foodstuffs and special diets to medical facilities impairs treatment processes and may contribute to an increase in deaths.
- Problems in supplying drinking water and disposing of wastewater and waste jeopardise the ability to guarantee minimum standards of hygiene.
- The disruptions to the transport and traffic infrastructure hamper not only the deployment of emergency medical services but also transport and relocation operations and also the supply of medical goods.
- The loss of communications services disrupts key medical supply interfaces: between the public and health service establishments (e.g. emergency calls), between health service establishments (e.g. provision of advance information

to hospitals by the emergency medical services) and within the establishments (e.g. between wards or functional areas of a hospital such as medical supplies, care, technical services).

- The losses of functions in the financial services sector mean it is no longer possible to make purchases or pay invoices. This primarily affects the public's ability to access pharmacy services and the pharmaceuticals trade.

In the light of the emerging consequences of a serious disruption to or loss of the functional interdependencies that these sectors have with the health sector, the authorities identify an urgent need for action.

HOSPITALS

After just a few days, hospitals face bottlenecks in the supply of blood products, insulin and special diets. Since most hospitals do not have their own hospital pharmacies, some medicines become scarce. As time passes, (special) waste that has not been disposed of and the lack of sterile products and fresh linen lead to hygiene problems (Göbel et al 2008, p. 22 f.; Steetskamp/Wijk 1994, p. 68). Problems intensify at specialist units such as intensive care wards. It becomes necessary to close other areas where ambient air has to be specially controlled or where controlled underpressure is required. Even hospital pharmacies that hold stocks of drugs and medical supplies sufficient to last 14 days are unable to meet demand. Some medicines can only be issued on a sporadic basis or cannot be issued at all. Attempts to draw on the medicine supplies of pharmacies, the trade and manufacturers prove inadequate after just a few days.

Only limited quantities of drinking water are available; in some cases it becomes necessary to use emergency drinking water wells located in the vicinity (Chapter III.2.3).

DOCTORS' SURGERIES

Doctors' surgeries are closed within the first few days. It is no longer possible to offer full decentralised provision of care. Doctors support the provision of medical care in hospitals and reception centres. Provided corresponding requirements are met, some larger doctors' surgeries are planned as ports of call for people seeking assistance and as support centres for hospitals.

PHARMACIES

A small number of pharmacies are given the role of distributing medicines, provided they are equipped with emergency power generators and provided sufficient stocks/continual replenishments can be ensured.

DIALYSIS CENTRES

Initially, there is no permanent transfer of patients, equipment and dialysis products to hospitals or reception centres and it is therefore necessary to establish emergency power capacities for dialysis centres. If this is not possible, patients with total kidney failure can only survive for a few days or weeks without dialysis treatment (ÄKV n.d.).[89] In such cases, managers realise the need to organise transfers for the people concerned.

OLD PEOPLE' S HOMES AND NURSING HOMES

If patients who require intensive medical care can be transferred and emergency power is available, old people's homes and nursing homes can continue to operate. However, the loss of toilets, inadequate fresh water and the supply of medical products, medicines or clean linen then become critical factors in determining the quality of care (Steetskamp/Wijk 1994, p. 59). But since many establishments are no longer working or are no longer able to receive adequate supplies, patients must be transferred to hospitals or reception centres; however, these establishments are also facing the same problems.

EMERGENCY MEDICAL SERVICES

The work of the emergency medical services remains heavily restricted due to the public's reduced ability to make emergency calls and due to the limited internal communications capabilities. There is a sharp drop in the medical equipment and products available in the ambulances. Moreover, if places are cut off by heavy snow falls and/or reduced road clearing services, it becomes necessary to deploy rough-terrain vehicles of the Federal Armed Forces within the framework of administrative assistance.

MANUFACTURERS AND TRADE

In the affected area, the production of medical and pharmaceutical products by manufacturers comes to a halt. There are no trade deliveries in the area, either. Where possible, warehoused stocks of temperature-sensitive products are moved outside the affected area. Transport operations from unaffected areas are organised to ensure supplies of pharmaceutical products over the longer term.

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89 If the power blackout lasts for several weeks the number of victims is likely to run into five digits (Reichenbach et al. 2008, p. 2).

CONCLUSION 2.5.5

The field of medical and pharmaceutical supplies, which is organised on a decentralised basis in accordance with the division of labour, is only able to withstand the consequences of a power blackout for a short time. After just 24 hours, the health sector's ability to function is considerably impaired. Over the next few days dialysis centres and old people's homes and nursing homes have to be at least partially evacuated. Most doctors' surgeries and pharmacies are closed. Domestic emergency call systems and medical equipment for domestic care can longer be used. It is no longer possible to continue the production and sale of pharmaceutical products within the area. The stocks at pharmacies that remain open and also the stocks at hospital pharmacies become increasingly depleted without continuous replenishments.

The interdependencies with other infrastructures have a negative impact. It becomes clear that the sector is crucially dependent on, for example, foodstuffs, fuel, water and means of communication. The makeshift supply of these goods and the exhaustion of internal management capacities reveal the health sector's limits of resilience. Over time, the few key central hospitals that are able to maintain an autonomous electricity supply or that have uninterruptible standby power systems find themselves overstretched in their attempts to compensate for the loss of outpatient and domestic care. Within one week, the situation in the sector deteriorates to such an extent that even with intensive deployment of regional assistance capacities, a total collapse in the supply of medical and pharmaceutical products and services is likely. The disastrous situation and the resulting increase in deaths make it necessary to enlist additional external support.

FINANCIAL SERVICES 2.6

Fast and secure processing of various financial services is of vital importance to a modern economy. Such services include:

- Execution of cashless payment transactions,[90]
- Acceptance and administration of deposits from the public
- Issuing of loans
- Administration and management of investments (e.g. securities, foreign exchange) and
- Operation of a multilateral trading system (stock exchanges).

90 In 2007, non-cash transactions via current accounts were made up of 6.9 billion direct debits and 5.2 billion transfers (Deutsche Bundesbank 2009a, p. 52)

STRUCTURES 2.6.1

The »financial services« sector is heavily dependent on a continuous and stable power supply. This is due to the mains-based information and communications infrastructures used for communications, for data management, for tracking and controlling flows of goods and money and for the transmission of payments and data traffic. These information and communications infrastructures represent the sector's »nervous system«. A failure of these infrastructures and the resulting difficulties in providing or inability to provide key financial services would have serious consequences for industry and society (EBP 2010, p. 34).

Financial services are provided by numerous players, including:

- Banks, insurance companies, other financial companies and other bank-related organisations (e.g. the Postbank, credit card organisations)
- Central banks (European Central Bank, German Bundesbank)
- Clearing organisations (e.g. Clearstream, SIX Group, other clearing networks/clearing groups[91])

The following section considers three areas of the overall »financial services« system in more detail: the system for deposits from the public and issuing of loans (banking services system), the system of electronic payment transactions and associated elements (payment transactions and data traffic system) and the system for administering and trading in investments of all types (stock exchange systems).

All sub-systems are based on extensive information and communications systems.

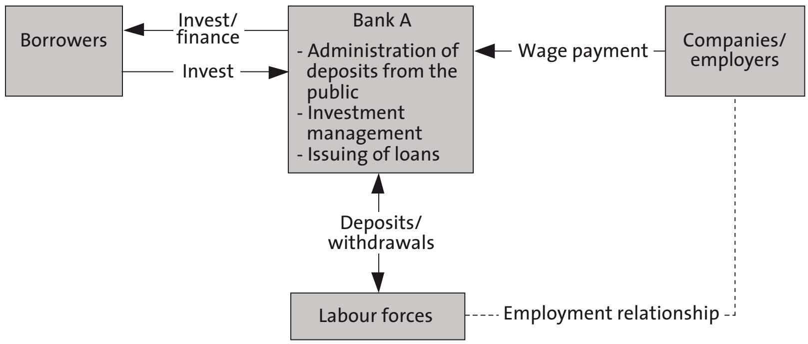
BANKING SERVICES SYSTEM

The system for deposits from the public and loan issues (Figure 22) essentially comprises the following elements:

- Employers (wage payers)
- Labour force (wage recipients, savers)
- Banks (banks, insurance companies and pension funds, other bank-related organisations (e.g. Post)
- Borrowers (companies, individuals)

91 In Germany, there are five »clearing networks« or »clearing groups« for inter-bank transfers; these are interlinked with each other and also process payments with other countries. These are the network of the German Bundesbank, the postal clearing network of the Deutsche Postbank, the network for private clearing transactions of the major, regional and private banks, the savings clearing network of the municipal banks and savings banks and the network for main clearing transactions of the cooperative banks.

FIGURE 22 BANKING SERVICES SYSTEM (SIMPLIFIED VIEW)



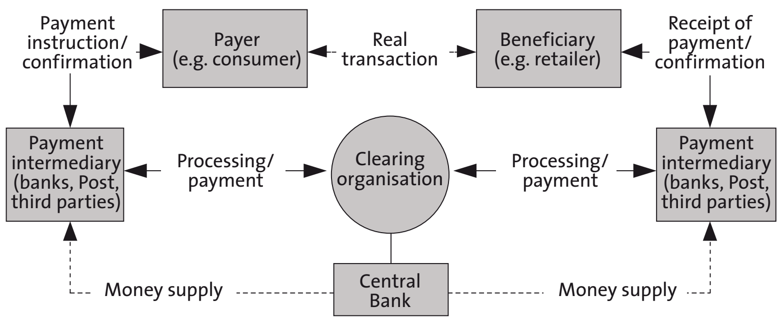
Source: EBP 2010, p. 36

PAYMENT TRANSACTIONS AND DATA TRAFFIC SYSTEM

Essentially, a payment transactions and data traffic system (Figure 23) comprises the following elements:

- Payers
- Beneficiaries
- Banks (actual payment intermediaries: banks, Postbank, third parties)
- Clearing organisations (clearing networks/clearing groups)
- Central banks (European Central Bank, German Bundesbank)

FIGURE 23 PAYMENT TRANSACTIONS AND DATA TRAFFIC SYSTEM (SIMPLIFIED VIEW)



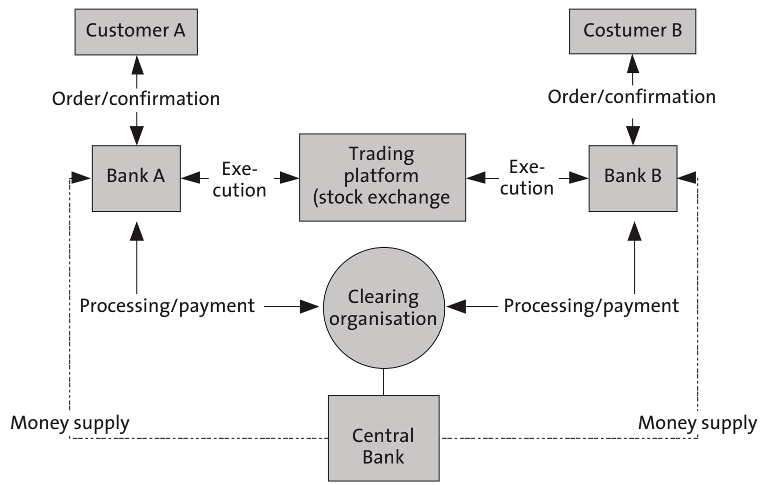
Source: EBP 2010, p. 37

STOCK EXCHANGE SYSTEMS

The stock exchange system (Figure 24) primarily comprises the following elements:

- Principals (for purchase/sale)
- Banks executing the orders of the relevant principals
- Trading platforms (organisations operating the platforms, e.g. stock exchange)
- Clearing organisations
- Central banks

FIGURE 24 STOCK EXCHANGE SYSTEM (SIMPLIFIED VIEW)



Source: EBP 2010, p. 38

LEGAL BASES 2.6.2

The relevant legal bases for this sector are presented in accordance with the aforementioned classification into the sub-sectors of the banking services system, the payment transactions and data traffic system, and stock exchange systems.[92]

92 The following statements are essentially based on the report on the legal analysis of the extent of regulation on IT security in critical infrastructures, which was drawn up by the BSI in 2002 and updated in 2005 (BSI 2005).

BANKING SERVICES SYSTEM

There is no specific set of precautionary statutory instruments for this sub-sector that, for example, explicitly differentiates between special obligations as regards contingency measures, security concepts, security officers, etc. Instead, legislation is mainly based on general clauses that stipulate organisational and security obligations that are to be fulfilled through interpretations of standards or through the specification of more specific details by the authorities (BSI 2005, p. 73). One example is Section 25a [1] of the German Banking Act (KWG), which stipulates special organisational duties for banking and financial services institutes. As well as dealing with aspects relating to electricity and/or IT (e.g. IT security measures), these obligations also cover aspects relating to internal auditing, documentation of business activities, etc. Section 25 [1] No. 3 contains explicit statements on IT-specific obligations; according to this clause, risk management must include establishment of an appropriate emergency concept, especially for IT systems. In addition to the German Banking Act (KWG), the Securities Trading Act (WpHG) also contains general clauses relating to IT security (e.g. Section 33 [1] WpHG) (BSI 2005, p. 75).

The statutory provisions must be implemented so that all IT-specific risks are covered – including, therefore, the consequences of a power blackout. Circulars, announcements and guidelines of the competent Federal Financial Supervisory Authority (BaFin) are of relevance in this context. Although these sub-statutory precautionary instruments are not legally binding, the people to whom they apply consider the respective rules as binding and implement them accordingly (EBP 2010, p. 9).

PAYMENT TRANSACTIONS AND DATA TRAFFIC SYSTEM

The regulations in the Bundesbank Act (BBankG) and especially Section 3 and Section 19 [1] No. 2 provide the statutory basis for the structuring of non-cash (i.e. electronic) payment transactions. According to this Act, bank-based processing of payment transactions within Germany and with other countries and also safeguarding the efficiency and security of payment transactions is the responsibility of the Bundesbank. However, since the Bundesbank Act does not stipulate any supreme powers of intervention in terms of exercising these authorities, the Bundesbank relies on cooperation with other relevant players in the payment transactions system (BSI 2005, p. 83) – at both national and international level.[93] The resulting guidelines of the umbrella organisations within the

93 At national level, for example, the Bundesbank participates in the governing organs of the Central Credit Committee (ZKA) and is therefore able to influence the structure of payment transaction agreements and thus the technical, organisational and legal framework for payment transactions in Germany. At European/international level, the Bundesbank is an integral component of the European System of Central Banks (ESCB)

banking industry form key elements of Business Continuity Management (BCM)[94] for the various players within the industry and aim to ensure efficiency and security for payment transactions (Deutsche Bundesbank 2009a). For example, extensive organisational, technical and personnel measures have been implemented to ensure processing of large-volume payments and also to ensure the supply of cash, refinancing of the banking industry and the management of currency reserves (BBK 2008a, p. 120).

STOCK-EXCHANGE SYSTEM

The statutory security obligations of stock exchanges are determined by the Stock Exchange Act (BörsG) (e.g. Section 1 [3], which requires measures to ensure the secure operation of stock exchanges) and also the Securities Trading Act (WpHG), along with sub-statutory regulations such as the stock exchange rules issued by the respective stock exchange councils[95]. For example, the fifth section of the Stock Exchange Rules of the Frankfurt Stock Exchange contains provisions on the electronic trading system; further details are then specified in special implementing provisions on technical facilities. Special implementing provisions issued by the Frankfurt Stock Exchange include provisions on technical requirements, (personnel) contactability and reporting obligations of trading members. For example, all hardware configurations used by trading members must receive prior approval from the Frankfurt Stock Exchange. Similarly, trading members may only use software provided by the Frankfurt Stock Exchange. In addition, trading members are obliged to draw up an emergency plan and to keep the required infrastructure and personnel resources ready (BSI 2005, p. 88 ff.).

Although IT protection measures are mainly standardised in sub-statutory regulations, the scope of regulations for the stock exchange sector is well differentiated and appropriately geared to typical threat situations faced by IT systems (BSI 2005, p. 96).

CONSEQUENCES 2.6.3

BANKING SERVICES SYSTEM 2.6.3.1

Major banks, insurance institutes, pension funds and other bank-like organisations have preparations in place to deal with power blackouts. Although their

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and as a member of the Committee on Payment and Settlement Systems (CPSS) of the central banks of the G10 countries, it plays an active role in developing corresponding guidelines and principles on operational risks relating to payment transactions (EBP 2010, p. 40).

94 BCM contains the measures to be taken to ensure operations can be maintained as far as possible in the event of a crisis or disaster.

95 A stock exchange council is a controlling and supervisory organ and has numerous tasks including issuing the above-mentioned stock exchange rules.

BCM processes vary in terms of managing power blackouts, they do exhibit numerous similarities (EBP 2010, p. 42). Generally, the individual business divisions within a company (e.g. payment transactions, investment management) define their critical business processes and specify how they will continue these in the event of a prolonged power blackout. Critical business processes refer in particular to activities relating to payment transactions and data traffic, data management and account movements, trade and securities settlement and also the supply of liquid funds (including the supply of cash) (Bankenverband 2004, p. 20 ff.).

SUPPLY OF CASH IN GERMANY

Cash plays an extremely important role in Germany, with 65 % of retail payments effected in cash (BBK 2008a, p. 119).

The German Bundesbank places the cash into circulation. To this end, it maintains a branch network throughout Germany which it also uses to maintain central strategic reserves (stockpiling of cash). The Bundesbank takes appropriate measures to ensure that this branch network can continue to function even in the event of a major crisis, i.e. that the payment of cash in the volumes required by the banks is guaranteed at all times (BBK 2008a, p. 119). The widespread distribution of bank notes (transporting of cash from the Bundesbank branches to the banks) is the responsibility of the banking industry (i.e. of the banks and of the private cash transport companies commissioned by them (Fabritius 2009)).

The cash provided by the Bundesbank branches is transported to the respective banks by specialist transport companies. The banks themselves make cash available to their customers via cash dispensers[96] or via serviced counters. Since this process must also function during periods of crisis, technical measures exist alongside general emergency plans in order to safeguard this business process; these technical measures can bridge a certain period of time if a power blackout strikes (EBP 2010, p. 44).

A basic technical means of ensuring these processes is to establish a corresponding emergency power supply for essential information and communications infrastructures (servers and data lines) and also for workstations and important facilities (e.g. safes). In addition, many organisations make provision for data and also staff to be transferred to an unaffected location (e.g. abroad, often to London) in the event of a widespread and/or prolonged incident. Some banks maintain alternative locations with a corresponding communications and information infrastructure in regions that are in some cases a considerable distance

96 In 2008 withdrawals amounted to 1.99 billion euros (Deutsche Bundesbank 2009a).

away. Banks also generally have a secure emergency power supply (diesel-driven emergency power system) that can last for around one week, but also have corresponding supply contracts with suppliers designed to guarantee a power supply if a power blackout were to last longer. During this period critical business processes could be outsourced to regions not affected by the blackout (EBP 2010, p. 12 ff.).

Round-the-clock availability of cash ranks as one of the most important financial services. If cash is not available in a crisis situation this further exacerbates the existing uncertainty felt by the public. Demand for cash is likely to increase rapidly in a crisis situation; it is estimated that on average, a citizen of Germany carries around 118 euros in cash (Deutsche Bundesbank 2009b, p. 40). It is therefore likely that if a power blackout lasts for a long time, banks and private cash-in-transit companies will be unable to guarantee the distribution of cash throughout the blackout. However, the Bundesbank states that in order to »manage an emergency or disaster situation ... special measures have been taken within the context of crisis management organisation« (BBK 2008a, p. 120).

0 to 2 hours

Following the sudden onset of the power blackout, the banks immediately start to implement the measures planned as part of BCM. Major banks have generally made provisions to ensure that key financial services (critical business processes) can still be guaranteed with the aid of an emergency power supply for the necessary information and communications systems. All banks' critical servers (containing data on payment transactions, investment management, etc.) are secured against power blackouts to ensure essential data are not lost.

Major banks also have a sufficient emergency power supply to supply employees' workstations (back office, counters). To start with, these can continue to work as normal. By contrast, many employees at smaller banks that have not made the necessary arrangements cannot continue to work. Since it is not initially known how long the power blackout will last, employees remain in the building for the moment (EBP 2010, p. 45 ff.).

The counters are initially still occupied and customers are still served. Sufficient cash is available. Cash transport operations that were underway when the power blackout struck are still able to reach their destination, although some delays are encountered due to mounting traffic problems such as traffic jams and closures (Chapter III.2.2). Some smaller banks have not made any provisions for continued counter operations and are forced to shut their counters.

Pure administration of deposits by the public and of (financial) investments is not affected at the start of the power blackout, provided the bank in question can supply the necessary back-office workstations with emergency power. Data are backed up and orders that had been sent to the corresponding trading platform before the power blackout can still be executed. Loans can also still be issued after the start of the power blackout.

In many parts of the affected area the members of the public are no longer able to withdraw cash from or pay in cash at cash dispensers. Cash dispensers do not generally have an uninterruptible power supply or an emergency power system and consequently stop working immediately the power blackout strikes. This does not apply to cash dispensers that are actually fitted to bank buildings and are connected to their internal emergency power system. However, the number of such cash dispensers is very small (EBP 2010, p. 46). Customers therefore queue up at the counters of their banks to withdraw money as it has since also become clear that it is no longer possible to pay for goods in shops by electronic means using debit or credit cards.[97]

Wage payments that have already been commissioned by an employer and for which there is corresponding cover at the bank are still executed. In some cases, it has already become difficult to issue instructions for new wage payments because the information and communications structures of many smaller companies have stopped working (EBP 2010, p.47).

2 to 8 hours

Operations in larger banks can largely still be maintained. Critical business processes in particular are ensured. However, in some areas it becomes clear that communications systems that are based on the public telephone network are gradually ceasing to function.

Counters are still manned, and service is still provided where this is possible and where appropriate provision is made as part of BCM. There are significantly more customers visiting the counters who wish to withdraw money from their accounts as cash dispensers are no longer working. Sufficient supplies of cash are available, and cash transport operations are still being carried out. The uninterruptible power supply at some smaller banks is no longer working or the counters have been closed from the outset. Some complaints are voiced by customers. In view of the uncertain situation, some transactions are initially recorded on paper so that they can be posted in the books at a later date (EBP 2010, p. 47).

While some employees who are unable to work (especially those in the back office of smaller banks) are sent home, others have to remain at work. They are especially deployed at the counters in order to serve the gradual rise in customer numbers as best they can. Along with an increasing demand for cash disburse-

97 In 2008 payments amounting to 2.13 billion euros were effected (Deutsche Bundesbank 2009a).

ments, staff also have to answer concerned questions about wage payments, transfers, etc. In some cases, chaotic scenes break out in banks where staff are not adequately prepared and/or where cash cannot be issued properly. In some locations it becomes necessary to enlist the assistance of the police – provided they are available. These banks decide to close early and resume (unfinished) transactions the next day – in the assumption that electricity will be restored by then (EBP 2010, p. 47 f.).

At the latest 8 hours after the start of the power blackout, the day's business is closed out as far as possible. No information is available on the anticipated duration of the blackout. Nevertheless, the managers and BCM officers in some larger banks start to consider next steps to cover the eventuality of a prolonged power blackout. They examine whether critical business processes should be outsourced to areas of the country not affected by the blackout or even to other countries. In addition, some employees of larger banks have to stay in the buildings overnight in order to ensure that the critical business processes can be continued the next day if the electricity supply has still not been restored by then (EBP 2010, p. 48).

Management of deposits by the public and of investments stops when banks are unable to provide their employees with workstations that are equipped with an emergency power supply. This especially applies to smaller banks. Larger institutes continue normal administrative activities at their most important branches until the end of the working day and where this is possible, use their data lines that are secured against power blackouts[98] to transfer the management of deposits by the public and of financial investments to branches that are not affected by the blackout.

Customers in the affected area find it increasingly difficult to communicate with their banks. In most cases it is no longer possible to receive/give instructions via the telephone (mobile and fixed network) or via the Internet. Investors and companies thus suffer financial losses due to lost profits (EBP 2010, p. 48). Fewer loan negotiations are conducted because the people concerned are unable to meet due to the traffic chaos. Inter-account transfers within the banking sector continue to function. Just a few hours after the start of the power blackout it becomes impossible to conduct negotiations via phone.

8 to 24 hours

Even on the day after the power blackout, the major banks are still largely able to maintain their critical business processes. However, working conditions deteriorate because, for example, most banks are unable to operate their staff restau-

98 Such data lines are generally based on glass fibre cables as the emergency power supply in the respective connected data centres is generally sufficient for their operation.

rants and lifts and heating no longer work. Lighting and workstations are still available. Around two-thirds of employees who are obliged to turn up for work do so (EBP 2010, p. 19). Together with the teams who have remained in the building overnight, they must maintain the critical business processes and man some of the counters. Communication is now only possible via secure data lines (payment transaction systems, connections to clearing organisations and trading venues, connections to other major banks) (EBP 2010, p. 49).

The counters at larger banks are manned and cash can still be issued. Money transport operations are still possible. Increasing numbers of people want to withdraw cash as purchases can only be made using cash.[99] Questions on salary payments and invoices also have to be answered. Smaller banks initially don't open at all and only perform back-office functions/critical business processes (EBP 2010, p. 49).

Management of deposits by the public and of financial investments comes to a halt, especially at smaller banks whose workstations are not equipped with an emergency power supply. Although larger institutes continue management operations, this is done with many restrictions (deterioration in working conditions, hardly any contact or no contact at all with customers/investors). However, they take initial steps to outsource these activities to unaffected areas.

Investors and companies in the affected area now have almost no means of communicating with their banks. It is no longer possible to give/receive instructions via the telephone (mobile and fixed network) or via the Internet, even if the investors/companies concerned have functioning terminals. They therefore suffer financial losses. Negotiations on the issuing of loans are only conducted in extremely urgent cases, provided the relevant parties are able to meet despite the traffic problems.

Since it is still assumed that the power supply will soon be restored and since the scale of the incident is not yet known in many places, managers and BCM officers only initiate the first steps for dealing with a prolonged power blackout at the end of the day following the onset of the blackout (e.g. transferring critical business processes to unaffected regions) (EBP 2010, p. 50).

24 hours to 1 week

In the week following the power blackout the larger banks are able to maintain restricted operations (i.e. maintenance of critical business processes and a – restricted – counter service). Towards the end of the first week critical business processes are outsourced to unaffected regions. To this end, the necessary staff have been transported, by buses from unaffected areas, to the alternative ven-

99 Although it would still be possible to pay with cheques these are now rarely used by private individuals. Moreover, very few businesses still accept cheques.

ues[100] that are kept on standby for such cases. Once at these locations they are able to perform the critical business processes using the redundant information and communications infrastructures that have been re-started by an advance team. However, additional staff from unaffected regions have to be mobilised because not all of the required staff were prepared to leave behind their families and homes in the affected area (EBP 2010, p. 51).

After a few days it is virtually impossible to make over-the-counter cash payments; this is in particular due to the fact that private companies are no longer able to transport the required volumes of money from the Bundesbank branches to their destinations. The Bundesbank does implement the measures planned for such a situation (distribution of bank notes independently of private transport operations) once it realises that the power blackout will last for some time. It is supported in this by other official agencies (e.g. the police) (BBK 2008a, p. 119). However, the size of the affected area means cash remains in short supply. The situation is compounded because transport problems and hoarding push up the prices of basic foodstuffs and other goods. The public is now very insecure as it is becoming increasingly clear that the power blackout will continue for some time (EBP 2010, p. 51 ff.).

At the end of the first week even the larger banks start to experience problems in maintaining their emergency power supply. The fuel supplies for the emergency power systems dry up and there are problems with deliveries of replenishment supplies. Most counters are therefore closed. Critical business processes are not affected by this as they have been outsourced to unaffected regions.[101] Smaller banks suspend their critical business processes and endeavour to prevent data losses (EBP 2010, p. 52). Management of deposits by the public and of financial investments has either been outsourced to unaffected regions or halted.

Companies that have not transferred their activities to unaffected regions or whose (smaller) banks are unable to continue administering financial investments via an alternative infrastructure are now no longer able to invest and obtain finance. They therefore suffer major financial losses. Negotiations on the issuing of loans and the actual process of issuing loans have come to a complete standstill within the affected area.

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100 An alternative venue is a building maintained by the respective bank at another location to which both data and also parts of the workforce can be transferred. Such buildings are equipped with the corresponding redundant communications and information infrastructure in order to enable them to take over the critical business processes.

101 In the Swiss financial sector, the provision of mutual support by banks in such a crisis situation through the assumption of some banks' critical business process by others that meet the corresponding prerequisities is being considered as an option (Steuerungsgremium BCP Finanzplatz Schweiz [September 2009]). »Business Continuity Planning im schweizerischen Finanzsektor: Eine Bestandsaufnahme.« (www.snb.ch/de/mmr/reference/bcp_2009/source).

The first businesses encounter liquidity bottlenecks towards the end of the week because on the one hand they are unable to generate any income and their customers can't pay any invoices due to the power blackout; on the other hand, numerous outstanding debts can still be paid (automated payments are still executed by the banks despite the power failure) (EBP 2010, p. 53).

A look at week 2

Thanks to the alternative venues, the major banks are still able to guarantee their critical business processes. Following the initial shortages in staff to operate the alternative venues, this has now been rectified by enlisting staff from unaffected areas.

Although the main branches of some banks have plans to open at certain times and to man a limited number of counters, by the second week most managers have decided to close the counters. Such decisions are based on a lack of security for staff (dissatisfied and in some cases aggressive customers), a shortage of cash, a threat to the emergency power supply and the fact that large numbers of employees stay away from work in order to look after their families and homes. Banks that store valuables in safes are exposed to a higher risk of break-in and require surveillance by private security firms or the police where applicable.

Measures adopted by the Bundesbank only enable the supply of cash to the public to be maintained to a limited degree.

Investors and companies who/that were unable to transfer their activities or do not have an alternative infrastructure are no longer able to invest or obtain finance and suffer financial losses. Many companies whose commitments continue despite the power blackout experience liquidity bottlenecks.

PAYMENT TRANSACTIONS AND DATA TRAFFIC SYSTEM 2.6.3.2

As previously outlined, the payment transactions and data traffic system between financial intermediaries (banks and bank-like organisations), the trading platforms and the central banks is extensively protected against a widespread and prolonged power blackout.

By contrast, (electronic) payment transactions and data traffic between beneficiaries and payers and their respective payment intermediaries are not protected. In many shops, when a power blackout strikes it immediately becomes impossible to make payments using a debit or credit card because the end terminals stop working. If a shop has an uninterruptible power supply, it should be possible to continue to make electronic payments for as long as the fixed telephone network lines still function (up to around 8 hours).

0 to 2 hours

After the power supply fails, uninterruptible power supplies and then emergency power systems at both payment intermediaries and also the corresponding clearing organisations ensure that systems can still function. This prevents the loss of data for electronic payment transactions. The communications infrastructures (secure data lines) also work, meaning (automated) exchanges between the payment intermediaries, clearing organisations and central banks can continue throughout the entire duration of the power blackout (EBP 2010, p. 62).

The activities of the European Central Bank and of the German Bundesbank are not restricted either, as these are also protected against a power blackout. In principle, the pan-European payment transactions system is not affected by the power blackout and continues to function throughout the power blackout.[102]

However, payers and beneficiaries do encounter problems. In many shops, when a power blackout strikes it immediately becomes impossible to continue to effect payments using debit and credit cards because the corresponding terminals (card readers) stop working. This means that cards can't be read and the corresponding payment instructions can't be sent to the payment intermediaries. Purchases can now only be made using cash. However, even instructions for distance payments (effected from home via the Internet) are no longer possible because the people who wish to make payments cannot use their computers and give corresponding instructions. During this phase, larger companies who are prepared for a power blackout and who have installed an uninterruptible power supply for their computers are still able to transmit payment instructions to banks or to receive confirmations.[103]

2 to 8 hours

In shops, purchases can now only be made using cash. In the first few hours since people have become aware of the power blackout and accepted it, this inability to conduct electronic payment transactions does not yet represent a major problem. Many people assume that the power will be restored in a few hours and delay their purchases. Others withdraw money from their banks, a process which is still largely unproblematic. Private individuals postpone the payment instructions they wanted to place via the Internet until later, again in the assumption that power will soon be restored. Larger companies who are prepared for a power blackout can continue to transmit their payment instructions for as long as the communications lines on which the Internet is based are still functioning.

102 This could be attributable to the measures that were defined and implemented in recent years by the »Crisis Management for Payment and Settlement Systems« working group that was set up in 2002 (EBP 2010, p. 62).

103 However, only for as long as the communications lines on which the Internet is based continue to function. This should at least still be the case in the first two hours after the power blackout (EBP 2010, p. 63).

8 to 24 hours

Some shops have opened despite the power blackout and offer products on a cash payment basis; in some cases the range of goods offered is reduced. Many people continue to assume that power will be restored in the next few hours. Purchases are therefore postponed until later. Other people withdraw money from banks because cash dispensers aren't working. However, smaller banks shut their doors. Even larger companies are now unable to issue payment instructions. In addition, many companies are running reduced operations, if at all, and many have closed completely.

24 hours to 1 week

In the first few days the public can still be supplied with cash from bank counters that remain open; demand for cash remains moderate as most people expect that the power blackout will end soon. Purchases are put off to a later date.

As soon as it is announced that it is not possible to say when the power blackout will end, concerns about supply bottlenecks grow among the public, not least because of the lack of means of payment. Chaotic scenes break out at some banks and in retail businesses as people attempt to obtain cash or to purchase daily requisites. The situation is compounded because some suppliers (can) no longer supply businesses – in some cases this is due to a lack of means of transport but in others it is for fear that deliveries will not be paid for. There are sporadic incidents of theft and looting.

A look at week 2

The measures taken by the Bundesbank to supply the public with cash are only partly effective because shops are empty and there are sharp rises in the prices of goods that are in especially high demand. There is also a rise in the number of mobile traders who sell daily requisites at vastly inflated prices. People who had a supply of cash or who have obtained cash via the measures adopted by the Bundesbank use this to purchase goods from farmers and other food suppliers (including some black market dealers). Exchanging valuable items for consumer durables and food tends to remain the exception (EBP 2010, p. 65).

STOCK EXCHANGE SYSTEM 2.6.3.3

Stock exchanges and trading platforms have today developed into a network of global interlinked hubs. Since the entire economy depends heavily on the stock exchange system, the stock exchanges and their operators must fulfil high requirements in terms of the resilience of their information and communications infrastructures. Stock exchange systems are largely protected against a power blackout (EBP 2010, p. 70).

0 to 2 hours

Thanks to its extensive contingency measures, Germany's most important stock exchange, the Frankfurt Stock Exchange, is initially unaffected by the power blackout and can continue to work as normal. The regional stock exchanges are also armed against a power blackout and are initially able to continue trading (EBP 2010, p. 71). Executing banks and the clearing organisations are able to maintain their operations because the information and communications infrastructures that ensure the corresponding critical processes are supplied with emergency power via emergency power systems. The necessary data lines (connections between banks, trading platforms and clearing organisations) also remain operational, as do the relevant workstations.

A few minutes after the power blackout strikes, problems are encountered with the connection between private customers (natural persons) and the executing banks. People who wish to place stock-market orders from their homes or from work are no longer able to do so because their communications infrastructures no longer work as the end terminals rely on electricity. In practice, stock-market orders can now only be transmitted on-site at a bank or via an analogue telephone.

Companies that trade professionally in financial investments and that have installed emergency power supply systems can still place orders with their banks.

2 to 8 hours

When power is still not available a few hours after the blackout and the effects make themselves felt outside the stock exchanges (traffic chaos, businesses closing early), the managers of the main stock exchange and of the regional stock exchanges affected by the blackout decide to end the trading day earlier than usual in order to enable staff to get home on time despite the emerging traffic chaos.[104] Only the BCM officers and small teams remain in the building overnight in order to ensure trading operations can continue the next day.

Executing banks and the clearing organisations can still maintain operations and remain in contact with all trading venues (including those in other countries).

People who wish to place stock-market orders from their homes or from work now find it difficult to do this and must in some cases visit their bank in person. However, few people tend to try and execute stock-market orders in the first few hours after the power blackout because of the other consequences triggered by the blackout.

104 This was the reaction of some stock exchanges during the 2003 blackout in North America (www.bis.org/publ/joint17.pdf, p. 19 ff.).

Until the end of the day, companies that trade professionally in investments can continue to place orders with their banks – provided they have the required communications infrastructures to connect to their trading venue (stock exchange) and provided these infrastructures are protected against a power blackout. Companies where this is not the case suffer financial losses. In some companies it also becomes clear that no consideration has been given to the fact that as public telephone lines stop working, so this affects the connections to their banks (EBP 2010, p. 71 f.).

8 to 24 hours

The main stock exchange even opens on the day after the power blackout. However, not all staff arrive at work (traffic chaos, people worrying about their own families/homes). For the moment, however, this does not restrict the stock exchange's ability to operate.

Even the regional stock exchanges open for trading. After a few hours, however, some stock exchanges' emergency power supplies based on UPS start to fail and traders have to resort to using past methods of pen and paper and have to call out orders to each other. Other regional stock exchanges have emergency power systems and continue to operate. However, as the trading volume declines at the regional stock exchanges in particular and since not all staff have arrived at work, the managers of the stock exchanges decide to end trading earlier than normal and send staff home.

People who wish to place stock-market orders now have no means of doing this. Some decide to visit the counters of their banks in person in order to place orders. Similarly, companies that trade professionally in investments have very few means of continuing activities and in some cases suffer serious losses.

24 hours to 1 week

Thanks to its extensive BCM measures, the main stock exchange remains operational, albeit to a somewhat reduced degree. This is due to some staff absences and to the fact that not all workstations can continue to operate. However, the core functions (i.e. trading venue operations) are still guaranteed, even for the longer term. Towards the end of the week problems are experienced where fuel for emergency power systems fails to arrive on time. Some regional stock exchanges decide to transfer their trading platforms to other stock exchange venues (abroad) that are not affected by the power blackout. A temporary closure is also considered.

The majority of people who wish to place stock-market orders now have to attend their banks in person. In most cases this is now only possible at larger banks. However, even these banks will start to gradually close their branches in the affected area towards the end of the week.

A look at week 2

The main stock exchange even continues to operate during the next week, albeit to a reduced degree. However, operations become increasingly difficult: Employees develop other priorities and remain at home. In addition, many employees have travelled to relatives and friends in order to await the end of the power blackout outside the affected area. By the latest at the end of the second week after the power blackout, all regional stock exchanges have shut and transferred their trading platforms to other stock exchanges (in other countries) that are not affected by the power blackout. Executing banks and clearing organisations are able to maintain their operations, mainly from regions that are not affected by the power blackout.

People who normally place stock-market orders have other priorities to worry about rather than concerning themselves with their personal financial investments. People who are staying with relatives and friends outside the affected area try to access their financial investments from there.

CONCLUSION 2.6.4

BANKING SERVICES 2.6.4.1

Within this sub-sector, all critical business processes are guaranteed by means of UPS or emergency power systems that can function for longer periods. These measures generally last until critical business processes can be outsourced to an unaffected area.

In line with BCM, corresponding teams are deployed immediately after the onset of the power blackout to ensure critical business processes are maintained. Some employees therefore have to stay overnight in the building. At the latest when the extent of the blackout becomes known after 2 days, measures are implemented to outsource critical business processes or to safeguard them on a long-term basis. Data traffic and payment transactions, data management and other critical business processes are therefore ensured throughout the power blackout. Banks who have valuables stored in safes must take special security measures. Steps are also taken to ensure the (emergency) supply of cash; this also requires the deployment of police.

Employees can continue to work on a limited basis for up to one week, and counters in larger banks can still be manned. However, employees suffer from a deterioration in working conditions. After one week at the latest it becomes necessary to gradually suspend operations. Very little damage to bank buildings is likely, although some branches are no longer able to carry out urgent repair and maintenance work (e.g. caused by frost damage).

Communication connections between the banks and customers gradually start to fail. After just a few hours, if both mobile and fixed-network telephony have stopped working, customers are only able to contact their banks by visiting them in person. Immediately after the power blackout strikes people are unable to withdraw cash from cash dispensers and this service is not restored for the entire duration of the blackout (people are also unable to make electronic payments in shops). The supply of cash to the public therefore threatens to collapse. Since cashless payment forms can't be used for purchasing, feelings of uncertainty and aggression grow among the population.

PAYMENT TRANSACTIONS AND DATA TRAFFIC

Technical measures (emergency power supply) enable payment transactions between banks, clearing organisations and central banks to continue throughout the power blackout. Prepared emergency plans are implemented. Selected banking personnel maintain critical business processes within banks. This means considerable pressures on the personnel resources deployed.

Businesses that are equipped with UPS and/or emergency power systems are still able to effect electronic payments for the first few hours. However, this becomes impossible as soon as fixed-network telephone connections stop working. Other businesses and shops are only able to process cash payments.

STOCK EXCHANGE

The technical, personnel and organisational measures prepared in the stock exchange sector are sufficient to ensure a stock exchange (and the clearing organisations) can largely continue operations throughout the power blackout. Trading venues are able to maintain operations thanks to their UPS and emergency power systems. Staff ensure continuing operations. Prepared emergency and alarm plans are implemented within the framework of BCM. Since the connections between private individuals/companies on the one hand and banks (executing parties) on the other are heavily disrupted due to the failure of the fixed-network and mobile telephone systems, hardly any stock-market orders can now be placed. When combined with the other consequences of a power blackout and also due to the restricted ability to place stock-market orders, this results in a sharp decline in trading volumes and corresponding financial losses. Trade starts to return to normal once professional investors have adapted to the new situation and have in some cases outsourced their business activities to unaffected regions.

A widespread power blackout thus has only a limited detrimental impact on the banking services system. Larger banks in particular can generally administer deposits from the public throughout the power blackout and can also maintain their connections with clearing organisations, the central bank and the stock exchanges. This is made possible by the emergency power supply systems and by the outsourcing of critical business processes to unaffected regions. Electronic payment transactions and data traffic between banks, clearing organisations and trading venues are also protected against a prolonged power blackout and are able to continue. Similarly, operation of the trading venues, and in particular of the main stock exchange in Frankfurt, is also protected against a prolonged power blackout and trading activities are not really affected to any significant degree. Regional stock exchanges represent an exception, however (EBP 2010, p. 78).

By contrast, disruptions to communication paths between the banks, clearing organisations and trading venues on the one hand and on the other hand individuals and companies who require financial services represent an Achilles heel within the sector. Consequently, most of the people who require financial services are unable to use them. After a certain time, therefore, transactions such as cash disbursements, salary transfers, borrowing, etc. become impossible. Payments cannot be made by card, either.

PUBLIC INSTITUTES – CASE STUDY ON »PRISONS« 2.7

PUBLIC AUTHORITIES AND INSTITUTES – PRELIMINARY REMARK 2.7.1

The operational capabilities of state institutions are also affected by a power blackout. Public administration, education, research, culture and also the aid organisations and public safety bodies face extreme challenges for which many players are unprepared (see Prognos 2009, p. 70 ff. on the below statements)

For example, the use of buildings for official and educational purposes or for university research and teaching becomes increasingly restricted and soon becomes impossible. Sanitary facilities stop working, water is in scarce supply and in many cases lifts, heating, air conditioning, ventilation and communications break down. In high-rise and multi-storey buildings the problems are compounded to such an extent they can soon no longer be used. Research projects at universities are interrupted or become unusable. Projects can be put back years because, for example, air conditioning or systems to ensure special conditions such as clean room conditions or other ambient conditions that need to be precisely maintained stop working. Materials and equipment can be damaged, and in areas of highly specialised research this could entail disadvantages in terms of location and competition.

In museums and archives there is a danger that exhibits and archived items will be damaged or become unusable as it becomes impossible to maintain the required ambient conditions. The failure of electrically operated security systems means valuable cultural and scientific goods face a significant risk of theft and looting.

Due in particular to the heavy reliance on information and communications systems, many public administration bodies (such as education authorities, registration services, health authorities) find themselves unable to provide services. During the power blackout it is difficult to handle and properly document relevant processes (e.g. births, deaths, serious illnesses, accidents). However, since server systems at least are equipped with UPS, it is possible to prevent large-scale losses of data records. The failure of information and communications systems also has major detrimental consequences in terms of the ability of security authorities and aid organisations to carry out their duties. An overload of incoming phone calls makes it impossible for operational control centres to provide key functions (Chapter III.2.1). Despite having emergency power generator back-up, some control centres are unable to fulfil their functions because the generators don't work or can't be replenished with fuel.

Police forces face sporadic break-ins and vandalism. They must ensure that any closures or traffic bans that are imposed are complied with. In some cases evacuations have to be carried out against the will of the people concerned.

Public safety is impaired due to the failure of fire and smoke alarms, meaning fires remain undetected for longer. The overload on the telephone networks or the loss of communications systems means it takes longer for the alarm to be raised with the fire brigades. Their deployment is delayed and fighting fires becomes more difficult. Such dangers can mushroom if, to make matters worse, no fire-fighting water is available (because the water supply is not functioning) (Chapter III.2.3).

Public lighting stops working over large areas, along with sensor systems such as alarm systems and surveillance cameras. The darkness encourages a rise in criminal activities. It is difficult to identify and arrest the perpetrators. However, problems are not only encountered in preventing crimes and arresting suspects or perpetrators; keeping them in prisons also becomes more difficult. The following sections provide a detailed case study on »prisons«.

»PRISONS« CASE STUDY 2.7.2

According to data from the Federal Office of Statistics (in Dünkel 2010), Germany had 195 correctional facilities accommodating 73,592 prisoners as at 31 March 2009. This means around 90 out of every 100,000 people are in detention facilities. The overall occupancy rate of facilities is 93 %. Capacity is only slightly exceeded in the federal states of Bavaria and Rhineland Palatinate. The percentage of women is around 5 %. Where possible, prisoners are separated according to the severity of the crime, the length of the sentence or the number of convictions. Just under 20 % of cases involve day-release, where prisoners are allowed to leave the detention facility during the day (EBP 2010, p. 153).

The type of sentence can be categorised into custodial sentence (53,334 people), young offender sentence (6,180), imprisonment on remand (11,385) and preventive custody (476) –i.e. where dangerous criminals are held in custody to protect the general public. Around 2,000 people were in civil confinement or in custody pending deportation. Assuming a standard occupancy rate of 85 %, most correctional facilities are overcrowded (Dünkel 2010).

A common form of custody involves the holding of individuals in temporary custody, for example at police stations. Collective detention centres are set up if it becomes likely that normal capacities will not suffice because of the volume of arrests at a special event (large demonstration, sporting event). Another form of custody is house arrest.[105]

LEGAL BASES 2.7.2.1

The main legal basis for the penal system is provided by the Prisons Act (StVollzG) of 16 March 1976. It includes regulations on the general implementation of custodial sentences, on organisation and responsibilities and on other special provisions for limiting freedom.

Preventive detention is regulated in Part 3. This specifies that preventive detention must be organised separately from custodial sentences in special institutes or in separate departments (Section 140 of the Prisons Act, StVollzG). According to Sections 136 to 138, prisoners with psychological problems or serious addictions must be accommodated in specially established institutes. As well as completion of the custodial sentence, the aim is also to facilitate a cure or to improve the prisoner's condition as much as possible. The necessary supervision, management and care are provided. Sentences are completed in closed institutes.

Sections 151 to 153 of the Prisons Act (StVollzG) regulate supervision via correctional facilities. Responsibility for managing supervision lies with the Land Administration of Justice. Supervision authorities can be transferred to correctional facilities. The Land Administration of Justice regulates the local and factual responsibilities of the correctional facilities in an implementation plan.

No explicit legal basis for security and contingency measures in the event of a prolonged power blackout was identified.

105 One future option for surveillance is electronic foot tagging, where the location of the individual is constantly transmitted to the relevant authority via the mobile phone network – this brings associated problems if networks are overloaded.

CONSEQUENCES 2.7.2.2

A key aim of correctional facilities is to protect the general public from further crimes. Even in a disaster situation, it is therefore necessary to keep prisoners in custody. Failure to do so would lead to significant consequences in terms of the public's confidence in the state's authority (EBP 2010, p. 156).

DAY-TO-DAY LIFE IN PRISONS

A prison day starts at 6 a.m. when prisoners are woken and cells opened up. The first block of work generally begins an hour later and lasts until 12 noon. Prisoners can work in the laundry, in the joiner's shop, in the bakery, in the kitchens or do cleaning. Lunch is from 12 noon until 1 p.m. and is usually taken in large rooms. The second block of work generally lasts from 1 p.m. until 4 p.m. This is followed by free time for the prisoners. This can include sporting activities, yard exercise or visiting other prisoners. In the latter case, a prisoner is locked up in the cell of a fellow prisoner. Sporting activities often involve team sports, when a large number of prisoners spend a certain amount of time in a confined space. Following the evening meal cells are locked at 9 p.m. at the latest.

Source: EBP 2010, p. 153 f.

In principle, there are two possible courses of action following a power blackout: The first involves continuing prison operations in a reduced format. This calls for a properly functioning emergency power supply system. This will ensure that at least the most important security functions (e.g. locking systems, movement alarms, surveillance cameras) are guaranteed. Lighting is reduced, only cold meals are offered and TVs/radios are switched off. Where a permanent emergency power supply cannot be guaranteed, the second option consists in transferring prisoners to other correctional facilities with an intact power supply once initial security measures have been implemented.

Where a functioning emergency power supply is in place, the availability of fuel (diesel) for the emergency power generators plays a decisive role. The length of time for which emergency power generators can operate is determined by stocks of fuel or by the ability to obtain external supplies. If supply points are available on the building it is in principle possible to ensure an adequate power supply using external mobile generators of the electricity supply companies or the THW.

0 to 2 hours

The emergency power system kicks in immediately the power blackout strikes. It ensures that the security elements (locking systems, sensors, alarms) and basic supplies (lighting, ventilation) still function. This requires regular checks to ensure the emergency power generator is functional and also adequate fuel supplies.

The initial period after the power blackout sets in is the most chaotic and most difficult to control. Staff and prisoners must adapt to the new situation. The main priority is to preserve/restore orderly processes. During this first phase priorities include suspending activities that are not urgently required, stopping leisure activities and locking up the prisoners. Visitors are asked to leave the building.

The consequences of a power blackout during this initial phase depend greatly on the time of day. If the blackout strikes during the night the prisoners are already locked up in their cells. The technology used in modern locking systems means that cells remain locked even in the event of a power blackout. A power blackout during the day proves more problematic. For example, large numbers of prisoners are in the canteen at lunchtime and in the evening. During the afternoon large numbers of prisoners congregate for sporting activities (especially where team activities are taking place). This means an increased risk of security staff losing control over the prisoners.

Computer-based administrative and organisational activities become increasingly impossible if computers do not have an emergency power supply and stop working. This makes it difficult, for example, to access prisoner data. This creates problems in allocating detainees to cells or generates organisational difficulties regarding the admission, discharge and management of prisoners. Other administrative activities needed to operate a correctional facility (such as the provision of food and other goods, personnel activities, etc.) can also be restricted (EBP 2010, p. 155 f.). Telephone communication is still largely possible.

2 to 8 hours

The prisoners remain locked up. Securing the cells and sections takes longer because the tense situation and a growing list of tasks means staff are in scarce supply and security elements are working on a reduced or slower basis (e.g. electronic locking systems now have to operated mechanically).

Ensuring operation of the emergency power generator now assumes top priority. This is the only way to ensure (reduced) operations and adequate monitoring of the prisoners. Besides checking the emergency power generator, another priority task involves clarifying deliveries of additional fuel. Such tasks become increasingly difficult as time progresses because the fixed-network and mobile telephone systems are only available for a limited time.

Problems can arise where prisoners are gathered in communal areas for a long time. Rumours and inaccurate information, changes in detention conditions and cancelled activities (sport, work) can trigger unrest and chaos.

It emerges that many prisoners on day-release have not returned to the correctional facility after work.

Where operation of the correctional facility cannot be maintained or can only be maintained with considerable difficulty, it becomes necessary to take initial steps towards transferring prisoners. However, communication and coordination and also mobilising external support are extremely difficult due to the failure of communications networks (mobile and fixed-network telephone systems, the Internet).

8 to 24 hours

With prisoners having been locked up for a long time and detention conditions deteriorating, unrest among prisoners grows still further. Staff experience high levels of nervous tension. Sporting activities for prisoners and work that are not absolutely necessary are stopped. Large gatherings of prisoners are mainly avoided. Locking up prisoners in their own cells to maintain security within the correctional facility represents the best option. During the night only a reduced level of lighting is available. Additional security staff are mobilised for the reduced operations under the emergency power supply and to organise a possible transfer of prisoners. The other consequences associated with the power blackout mean the police cannot be relied on to provide support.

Providing prisoners with food now becomes an additional, urgent problem. As a provisional measure, makeshift cold meals are prepared from existing supplies. Drinking water is available where water is still being distributed via pipeline networks (EBP 2010, p. 159) (Chapter III.2.3).

There is the issue of ensuring adequate personnel. It must also be expected that staff who are due to work on the upcoming second shift will arrive late or will be unable to get to work due to disruptions in local public transport and individual motor transport. This compounds the staffing situation that has already become tense due to the power blackout's consequences.

24 hours to 1 week

Almost all areas relating to operation of the prison become reliant on external sources – e.g. the provision of food for prisoners, the support of additional security forces to help make the prison secure and fuel deliveries for the emergency power supply. The collapse of the telephone system hampers communication with external companies, agencies and authorities.

Medical care becomes critical after just 2 to 3 days. Hygiene conditions also become problematic – not least due to shortages in or the failure of the water supply and wastewater disposal. There are no deliveries of fresh laundry. Together with the constant deterioration in food supplies, this creates constant unrest among the prisoners.

The risk of attempts to free prisoners and breakouts increases. Security and surveillance of prisoners thus remain high priority tasks. External protection is increasingly enhanced because of the likelihood of attempts to free prisoners.[106] Since the police make numerous arrests (e.g. of looters) in a bid to maintain public order and the individuals are soon transferred to the correctional facilities on capacity grounds, the problems faced by the correctional facilities are further exacerbated.[107]

Staff are likely to experience increasing levels of stress and overtiredness. The situation at correctional facilities is made worse by the fact that staff on the next shift find it difficult to get to work because of the traffic problems (traffic jams, loss of the local public transport system) and stay away in some cases. Due to the other consequences of the power failure for other sectors, the police and other services that are also experiencing severe pressures cannot be relied on to provide effective support for the correctional facilities.

The situation in the individual correctional facilities primarily depends on the ability to supply prisoners with food and drinking water, on hygiene and on security (staff availability). Transferring prisoners is considered in many cases due to the poor custody conditions and because the correctional facilities in question are unable to improve the situation to any great extent despite external assistance.

CONCLUSION 2.7.2.3

If the emergency power supply is working[108], basic operational functions can be maintained for a limited time. These functions include in particular securing the prisoners and the supply of essentials such as lighting, ventilation and heating. All security elements, building facility components and IT systems and means of communication that are not supplied with emergency electricity stop working. If

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106 This task could be carried out by the police or – depending on corresponding decisions by the disaster control authorities – within the framework of general securing of populated areas by the Federal Armed Forces. However, this would presumably exceed technical assistance by the authorities and would then be based on Article 35 [2] and [3] of the Basic Law (GG). In such a case the Federal Armed Forces would have powers of coercion and intervention.

107 Examples from history (e.g. power blackouts in the USA in 1977 and 2003 or power blackout in Brazil in 1999) have shown that criminality can increase during a power blackout if certain underlying conditions prevail. The police can mostly accommodate the first arrests in cells at police stations. However, if the occupancy capacity is exceeded, prisoners must be transferred to correctional facilities. The problems encountered at these facilities are then compounded still further (EBP 2010, p. 160).

108 For disaster control purposes it could be of major significance whether the emergency power infrastructure is largely serviced internally or by an external service provider and whether it is upgraded in the event of heavy loads. Service provided by, for example, an external facilities management company would undoubtedly be overstretched in the event of an extensive power blackout, not least because of the wealth of enquiries faced by the company.

an emergency power supply stops working or if the fuel reserves stored at the detention facilities dry up then the correctional facilities must be evacuated.

Even where an emergency power supply is in place the pressures in terms of problems increase rapidly. Because they have to be locked up on a permanent basis, prisoners are exposed to high levels of psychological stress as they are unable to participate in leisure activities and work and are unable to communicate with other prisoners. In addition, the constant deterioration in hygiene conditions, inadequate food supplies and an absence of heating lead to unrest, health problems and sickness. This situation is compounded because medical care becomes more critical the longer the power blackout continues. The risk of unrest and dissent among prisoners grows, especially if the number of detainees rises over time due to an increase in criminality in the affected area (more arrests). Towards the end of the first week the dramatic deterioration in custody conditions therefore makes it necessary to consider transferring prisoners (EBP 2010, p. 160).

BEHAVIOUR-RELATED CONSEQUENCES OF A POWER BLACKOUT AND THEIR DETERMINING FACTORS 3.

People almost take a reliable, efficient supply of electricity in their daily lives for granted and rarely pause to think about the issue. For example, modern households have a large number of technical devices that require electricity: tools, machinery, apparatus and equipment serving a variety of different functions. The everyday technology we use includes craft, household and gardening technology, communications and entertainment technology, as well as computers, heating, ventilation and refrigeration systems. Some systems are interlinked with each other, equipped with control units and connected to external supply networks (energy, information).

Numerous everyday activities such as heating, ventilation, refrigeration, cooking and washing are made possible by operating technical devices that have largely replaced human sensory motor actions but that also offer functions that would otherwise be impossible. However, almost all activities outside the sphere of private households such as mobility, work, leisure and associated sectors of the economy also involve technology and therefore also rely on electricity.

If the extensive supply network breaks down, everyday activities are called into question and disconnected from the technical systems. According to Vierboom and Härlen (2009, p. 3) in an expert report for the TAB, the »associated threats« do not only affect vital material services. »The provision of psychological services in the context of an extensive, medial and concrete establishment of one's own self is also affected.« The collapse of technical structures as described in the previous chapters prompts an individual to doubt his »ability to control his living conditions« (Dombrowsky et al. 2009, p. 256).

A small number of reports and analyses have been produced on the behaviour of the public in a – short-lived – power blackout (see Lorenz 2010). However, there are no empirical findings on people's behaviour resulting from the consequences of a prolonged power blackout. The rest of this discussion is therefore focussed on the development of theories on the psychological determining factors and on behaviour-related consequences of a prolonged power blackout. The observations and theories are also intended to provide a basis for research questions that can be considered and answered through more extensive analyses. This cautious approach to the issue is also attributable to the inadequate levels of knowledge on the behaviour of individuals during a threat situation. For example, Ungerer/Morgenroth (2001, p. 15 ff.) state that there are »hardly any« research findings and especially specific, detailed statements on human behaviour in real threat situations – which a prolonged power blackout would create. Whereas the »human factor« is frequently addressed (often as a cause) when describing and analysing the origins of a disaster, less attention is placed on »how people feel in such crisis situations«.

PSYCHOLOGICAL DETERMINING FACTORS 3.1

Every citizen needs/uses electricity – every day and every night. People usually have little knowledge of the production and supply process, of physical and technical aspects surrounding »what comes out of the plug«. They seldom reflect on exactly how many devices and processes rely on electricity or on quite how heavily everyday activities depend on electricity.[109] Consequently, power blackouts are »not an issue« for the general public −a fact that was, for example, ascertained by a (non-representative) survey of citizens in Zurich. Minor power blackouts are quickly forgotten and leave no lasting impression. The citizens questioned did not consider power blackouts to be a threat, especially not to life and limb. They therefore don't make any preparations to deal with a power blackout (Stiftung Risiko-Dialog 2007, p. 14; see also Palm 2009).[110] It is therefore not surprising that citizens are not keen to spend more money to increase

109 »There is very little knowledge and awareness of the power supply. There are the two 'ends' of production and consumption. There is no perception of the intervening networks.« (Stiftung Risiko-Dialog 2007, p. 22; see also Palm 2009)

110 This fatalism is also reflected in the personal reports on the »snow chaos« in the Münsterland in 2005 that resulted in a power blackout lasting up to 5 days. »The next disaster will again take us by surprise and hit us full in the face.« (Cantauw/Loy 2009, p 119 and 184); opposing reactions are, however, also evident. »Let's hope nothing like this happens again, but discussions are needed on the issue of 'emergency power supply'.«

reliability (Silvast/Kaplinsky 2007, p. 46; see also Brayley et al. 2005, p. 4; Palm 2009).

Another aspect to consider is the fact that people generally tend to think they are well prepared for a disaster situation. One reason is that in general, the potential danger presented by risks and threats is underestimated. This also applies to power blackouts and the resulting consequences. According to a survey by the German Red Cross (DRK), the majority of Germans believe they could look after themselves even during a power blackout lasting 2 weeks (Emnid 2008).

Such an attitude presupposes an expectation of reliable supply that is so intrinsic that any thought of it being threatened generates »feelings of helplessness« and must be fought off. In this context, Vierboom and Härlen (2009, p. 7) use the term of collective suppression. This is connected firstly with the fact that people do not like to admit dependency and helplessness and secondly with the fact that in its pure form, electricity is dangerous and must therefore be cultivated. Consumers have an almost childlike dependence on their electricity supply companies but do not like to admit this.[111] In addition, the supply and the use of electricity are characterised by the fact that electricity is seldom experienced directly, »only via devices that use power, meaning people remain unaware of the fact that they are using electricity when a device is used and only realise this when a power blackout strikes or an electrical accident occurs«.

The importance of electricity as a »constituent operating energy for everyday life and everyday culture« becomes clear with personal computers, mobile phones and televisions (Vierboom/Härlen 2009, p. 8). Devices that are powered by electricity make people feel they are not alone and that they are, so to speak, constantly networked with the »current« of society. Examples include constant contactability via e-mail, phone and mobile phone, chatting via the Internet or moving images on large-format screens. A study by Stiftung Risiko-Dialog revealed that the loss of communication »with the outside world« is a key concept mentioned by those surveyed when considering the consequences of a power blackout. »For many people, electricity and the technologies it operates (televisions, radios, telephones, Internet communications) represent a link to the outside world. If this is halted, people feel cut off and isolated. They cannot obtain information on what is happening and on what is being done, nor can they obtain help if required. This inability to communicate leads to uncertainty that is highly unsettling.« (Stiftung Risiko-Dialog 2007, p. 16). Inability to communicate by telephone, mobile phone, the Internet and radio is also a dominant theme in the more than 40 experience reports on the power blackout in the Münsterland in

111 In a survey of the population on their experiences and opinions concerning the power blackout in London in 2003, 55 % of the people surveyed stated that they were not concerned about a possible repeat of such an event (Brayley et al. 2005, p. 3).

2005 that were collected by the Commission for Ethnology and Folklore in Westphalia. The resulting uncertainty is well documented (Cantauw/Loy 2009).

Vierboom and Härlen argue that the increasing technological and media-based character of trade is accompanied by a decline in ego strength[112] among large parts of our society. Consequently, depending on its duration and on the individual constitution of the electricity user, a power blackout represents a »threat to an individual's own identity« (Vierboom/Härlen 2009, p. 8). Dependence on something that is foreign is felt immediately. »The media-based corset that supports us through life and that is fed by electricity is lost. From that moment on an individual relies on simple, archaic and physical forms of everyday activities.« (Vierboom/Härlen 2009, p. 9) The way in which mass media communication loads subjective experience with relevance in the midst of the disaster is also reflected in the following quotation: »The overall extent of the disaster became visible on the TV.« (Cantauw/Loy 2009)

The social consequences of a power blackout are akin to a »cultural breakdown«: Traditional patterns of experience and behaviour are called into question; previous ordering principles no longer provide structure and orientation. It is important to consider that »order« as a principle does not cease to exist; what does, however, disappear are »previously existing and familiar connective and assertive forces« (Dombrowsky et al. 2009, p. 262). In contrast to other disasters (such as a pandemic), a power blackout also has a unique structure in terms of time. It occurs suddenly, without any advance warning and there is total uncertainty surrounding its duration. Both factors hamper an individual's ability to deal with the situation.

If the blackout lasts for only a short time, it is not necessary to confront the reappearance of what has been suppressed, to develop an awareness of dependencies, to activate one's inner self.[113] Paradoxically, the short nature of the power blackout seems to prove the reliability of supply.

By contrast, a power blackout lasting for several hours or 1 or 2 days could make people more aware of dependencies and of the consequences of a blackout (for the following see Vierboom/Härlen, p. 11):

› The unquestioned expected stability in terms of the supply's previous ability to function is cast aside. When an individual turns on the radio or television or tries to use the fixed-line network to make a phone call and discovers that these devices don't work without electricity, this is at the latest the point

112 In this context, ego strength especially means a (relatively) low dependence on environmental conditions.

113 In a survey of Dutch citizens on a power blackout in 2007, 40 % stated that they continued with their normal everyday lives; around one quarter attempted to obtain information. Nobody stated that they panicked (Helsloot/Beerens 2009, p. 66).

when he realises that wider areas of customary everyday life are now disrupted. The lack of information (e.g. on the expected duration) is felt particularly strongly (Palm 2009).

- The sudden silence of media and telecommunications technology (radios, TVs, PCs, mobile phone systems), of household appliances (coffee machines, cookers, dishwashers, fridges and freezers), of personal hygiene appliances (razors, hair dryers) and of domestic technology (heating systems, alarm systems, lighting, doorbells, electrically operated shutters) immediately highlights the fact that the modern world in which we live is extensively reliant on media, that the »current of everyday life« is also one of the noises. However, it also becomes clear that only a few everyday tasks can really be accomplished by hand.
- Retaining a familiar structure to everyday life proves difficult without electricity. Functions that are taken for granted no longer work. Garage doors won't open, water leaks from freezers as they defrost, surveillance cameras stop working, and appliances can't be used for heating, cooking and cooling.
- Some people are unable to withstand the sudden realisation of dependency and the need to readjust for an uncertain time. This translates into greater or lesser physical forms of »de-regulation« through the consumption of alcohol and violence and also into archaic types of group formation such as mobs.
- However, the experience of the breakdown in everyday organisation also leads to processes and to the formation of structures where social cohesion is sought and established between attachment figures or family connections[114]. Attempts are made to bring and keep the family together. If it becomes necessary for an individual to leave his familiar environment, he will only do this with his relatives.
- The experiences of a power blackout that is limited in terms of time are also ambivalent. As well as experiencing feelings of uncertainty and irritation, people are also fascinated by the incident (Vierboom/Härlen 2009, p. 12 and 13).

During a power blackout that lasts for several days or weeks it can firstly be expected that – due to stress, emotions, affects, cognitive blockages – the process of civilisation »retreats« (Dombrowsky et al. 2009, p. 257). Some individuals and groups become less considerate, more aggressive and more prone to violence, and thus abandon the established standards of social interaction.[115] On

114 In disaster research, the role of the family/of the social network it represents is mainly described in positive terms, including in the context of a positive contribution to »disaster preparedness« (see Kirschenbaum 2006). This is also a theme in the experience reports of Cantauw/Loy (2009).

115 At the end of the 1930s the sociologist Norbert Elias presented his studies on the »civilisation process« (Elias 1989). He reconstructed how a civilisation of human behaviour has developed since the Middle Ages. People learn to curb their affects, they consider the consequences of their actions, their propensity to violence falls (without however

the other hand, types of reaction and behaviour are revealed that enable people to »distance« themselves from extreme situations and events in such a way that potentially aggressive, panicked or apathetic reactions do not materialise or are overcome by the individuals in question. If self-control, cooperation, empathy and a willingness to help come to the fore, »the individuals concerned regain their sovereignty and also a feeling that the overwhelming can be overcome« (Dombrowsky et al. 2009, p. 263; see also Schutzkommission 2006, p. 45).

All measures by authorities and aid organisations, all technical support and assistance and also all human affection must ultimately aim to mitigate material shortcomings and psychological pressures in order to enable people to develop such a conviction. This would also help to activate »social capital« within society (Murphy 2007), i.e. the potential of non-professional helpers to provide assistance.

THEORIES ON THE BEHAVIOUR-RELATED CONSEQUENCES OF A PROLONGED POWER BLACKOUT 3.2

The following section discusses possible types of experience and behaviour associated with a prolonged power blackout[116] in theoretical and exaggerated form. The statements are largely based on the report by Vierboom/Härlen (2009, p. 15 ff.) and represent theories for discussion.

A first dimension of the prolonged power blackout is the manifest threat to customary »everyday operations«. Actions involving the body such as cooking, eating and personal hygiene are taken out of step, as are cultural communication tools. The power blackout means these actions have to be re-thought and practised. For example, face-to-face communication replaces communication by technical means and assumes a new importance. The desire for and the dissemination of news and information manifests itself in rumours that in the circumstances are deemed an »intensive quest for information« (Turner 1994). In addition, thresholds that have been established and guaranteed through civilisation and law can become questionable and threatened. »Boundaries are dissolved; examples include violence, alcohol consumption, sexualisation, looting, mobs, the formation of gangs. However, the power of de-differentiation also extends to more subtle areas. Houses and apartments gradually reduce to one room, school teaching is cancelled or is continued using »on-board resources«, physical distances disappear, inhibitions are lost, hygiene standards can no longer be main-

disappearing completely), eating, drinking and interaction with one another become increasingly uninhibited and casual.

116 Ungerer/Morgenroth (2001, p. 112) refer to the behaviour of people in a threat situation as »disclosure documentation of emotional/affective, cognitive and ethical/moral dispositions« of human beings.

tained, special skills and professional expertise are no longer in demand, personal tastes and extravagances are suppressed, etc. This dissolving of borders is heightened by the fact that the power blackout strikes people unprepared and by the fact that there is uncertainty surrounding its duration. The experience of time thus also becomes de-differentiated« (Vierboom/Härlen 2009, p. 16)

Feelings of helplessness develop despite efforts to maintain order and despite hope that the power blackout cannot last for ever. This is followed by »attempts at explanations, attempts at pacification, morale-boosting talk, obtaining information, making contact, drawing up organisational plans and allocating roles for purchasing food, cooking, eating, personal hygiene«. Yet the realisation remains that one is almost helplessly exposed to the conditions and consequences of a prolonged power blackout (Vierboom/Härlen 2009, p. 16 f.). However, any conception of humans as helpless victims of disasters is misleading – not least because experiences of disasters have shown that more people are saved by non-professional helpers than by members of the aid organisations.

The resulting consequences for people's perception of tension and their means of coping with this are by no means uniform: »On the one hand, the loss of order and the breakdown of familiar functions and tasks releases energies that float freely and can translate into fears and psychotic reactions. On the other hand familiar unities are replaced by new unities and focuses, for example in the form of complex, long-winded energy-sapping processes to procure food.« There is only a modest re-establishment of order with a view to achieving a functioning everyday existence – »people are happy if at least something starts working again« (Vierboom/Härlen 2009, p. 17).

The aforementioned processes of the dissolution of borders intensify as the disaster unfolds. »To begin with, a power blackout is at most annoying, uncomfortable, perhaps unsettling for some, while for others it is exciting and irritating in a positive way. Then, however, public order begins to disintegrate.« A shortage of drinking water, food shortages, aggressive altercations, increases in fatalities in hospitals and old people's homes are signs of the failing efforts to manage the situation and provide assistance. The concentration of such circumstances »acts like a mixing bowl, where everything is thrown in together. In a state of extreme de-differentiation, an extensive conglomeration of disasters opens up threatening many fatalities and provoking increased efforts by individuals to protect and arm themselves.« (Vierboom/Härlen 2009, p. 17)

Finally, the reflections so far need to be condensed into hypothetical coping strategies and patterns of behaviour that could materialise during a prolonged power blackout. This typification serves to combine a wide variety of behaviour patterns[117] that indicate interpersonal and intrapersonal differences. The discussion is based on adapted versus deviant behaviour, each in combination with ego strength and ego weakness (according to Vierboom/Härlen 2009, p. 17 ff.).[118]

EGO STRENGTH IN COMBINATION WITH ADAPTED BEHAVIOUR

This type of behaviour is characterised by the self-determined goal of replacing the emerging chaos with a newly structured order based on traditional rules. For people who exhibit this type of behaviour, protecting family members or sensitive parties such as partners, friends and close acquaintances is especially important and serves to motivate them.

Adherence to culture describes an individual who keeps a stiff upper lip even during the disaster and who takes on responsibility (Wallenius 2001, p. 158), who will not let himself go and who pursues his goals with determination. People who fall into this category include people who have survived even seemingly impossible situations by displaying ego strength and a life-affirming attitude.

Maintaining order and actively managing the disaster represent the guidelines that form the basis for the behaviour of people who attempt to maintain calm and retain an overview while also playing an active role. They have a high level of controlling conviction. This could manifest itself by individuals taking on management tasks in a considered and responsible way. They could also be classified as self-declared »custodians of order«, which is a somewhat problematic role (Vierboom/Härlen 2009, p. 19).

Vierboom and Härlen (2009, p. 20) describe a special form of ego strength as rustic survival. This category includes individuals who can manage for some time without a civilisation-based environment (e.g. people with pathfinder and camping experience, lone fighter training, survival training and people who can manage without the frequent use of lots of technical equipment).

EGO STRENGTH IN COMBINATION WITH DEVIANT BEHAVIOUR

Coping strategies from the criminal-deviant spectrum are also target-oriented, but are characterised by deviant behaviour that uses the threat situation faced by public order for aggressive action and criminal activities.

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117 In emergency psychology this fact is attributed to a set of different biological, sociocultural and psychological factors (Lasogga/Gasch 2008). This is confirmed by (empirically backed) disaster research.

118 Adapted behaviour means behaviour geared to moral rules, rules of law and rules of public order; deviant behaviour goes against these standards. Ego strength means a relatively low dependence on external conditions due to continuous character development; ego weakness refers to »a lack of anchor and structural weakness« and a relatively high dependence on surrounding conditions.

Subversion: This form of coping is furthest removed from socially accepted standards. It includes forms of sabotage, organised and serious breaches of the peace and terrorism. Planned actions aimed at undermining existing social order render this form dangerous.

Intelligent forms of criminality exploit the situation caused by the power blackout (e.g. in the form of targeted break-ins at banks or shops).

Opportunistic criminality also exploits the circumstances, but with less planning involved (pick-pocketing, robbing kiosks).

EGO WEAKNESS IN COMBINATION WITH ADAPTED BEHAVIOUR

Helplessness can be triggered by an individual feeling he has no influence over events. Helplessness that needs management by others can represent a form of coping.

- Overload and passivity: Many people find themselves overtaxed by the consequences of an extensive power blackout. They don't know how to help themselves, tend to have panic reactions[119] or withdraw passively (»freezing«). A feeling of suffering is combined with a strong need to manage. Such people also align themselves closely to others and behave in the same way as them (»passive following«) Wallenius 2001, p. 163).
- Apathy and depression: A combination of stress and overload can lead to trauma being expressed to a greater or lesser degree. Traumatised people have »looked too deep into the abyss«. They have no drive and tend to give up.[120]

EGO WEAKNESS IN COMBINATION WITH DEVIANT BEHAVIOUR

Forms of behaviour that are characterised by destructive and aggressive conduct and that border on the psychotic are usually associated with ego weakness. They are also a form of coping with a situation in which there is little to hold on to.

- Looting, vandalism: Groups such as hooligans or anarchists are driven by the chaos and exacerbate the chaos (Vierboom/Härlen 2009, p. 21). Spontaneous mobs, looting and unrest represent an expression and a consequence of a disordered and uncertain situation.
- Sexually aggressive empowerment: From extreme situations such as war and disasters, forms of sexually aggressive behaviour that especially appear when the »corset« of cultivation comes loose are known as »cultural failures«.

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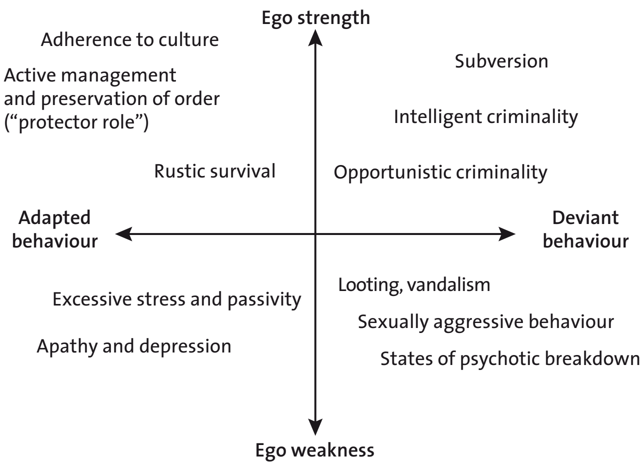
119 American literature in particular heavily emphasises that panic reactions tend to be rare (»panic myth«).

120 Ungerer/Morgenroth (2001, p. 121) refer to »mental unfaithfulness« if the threat situation is not confronted.

› Psychotic plundering may also occur if the power blackout continues for a long time. In heightened form this reflects a general state of uncertainty among large sections of the population.

Figure 25 summarises the above statements.

FIGURE 25 **FOUR TEXTBOOK FORMS OF BEHAVIOUR**



Source: According to Vierboom/Härlen 2009, p. 19

The above statements describe four textbook behaviour clusters that are exaggerated from a theoretical point of view. Overall, it can be said that the described forms of deviant behaviour will probably be found among only a small section of the population. The forms of adapted behaviour (ego strength and ego weakness forms) will represent the majority of coping strategies (Vierboom/Härlen 2009, p. 21). Social resources, i.e. the ability for one or more individuals to provide emotional support, should help significantly in overcoming individual critical situations and the associated on-going stress (Lasogga/Gasch 2008, p. 144). This assumption is supported by findings on disaster research. According to these findings, it appears plausible that popular assumptions on people's behaviour in threat situations – which are often disseminated by media – do not apply across-the-board (Dombrowsky/Schuh 2008). According to Quarantelli (1985, p. 8 ff.), for example, experience shows that individual conduct and behaviour in disasters cannot be described as mainly panic-stricken, anti-social and passive. Reality shows a very different picture: relatively controlled (including a rational decision to escape), altruistic, supportive and energetic actions are far more typical and frequent than panic-stricken, anti-social actions (see also Wallenius 2001, p. 158; Nye 2010). Many case studies on threat situations such as earthquakes, fires in underground rail stations or shipping disasters (e.g. Cornwell et al. 2001) emphasise the pronounced desire to help even where underlying conditions are critical. Some reports also provide evidence of this in the case of power blackouts (e.g. Nye 2010 for New York; see also Murphy 2007, Yuill 2004).

However, such behaviour does not necessarily have to lead to self-abandonment and a neglect of one's own safety/security and interests. A phase where assistance is provided can thus switch, more or less abruptly, to a phase involving purely egoistic behaviour, if circumstances and events become life-threatening for helpers (Wallenius 2001, p. 182).

The above deliberations and hypotheses undoubtedly need to be verified and developed in order to provide a sounder basis for understanding the psychodynamics of dealing with people faced with a gradually unfolding disaster.

NEED FOR INFORMATION AND RESEARCH 3.3

Attitudes and behaviour of groups and individuals in disaster situations represent an area that has not been sufficiently researched. At the same time, however, a number of assumptions exist – especially concerning anticipated antisocial, apathetic or panic-stricken behaviour by the public (»panic myth«) – which would probably not withstand examination. Further clarification is therefore also required regarding power blackouts as a type of disaster; these could build on the few available reports and analyses on power blackouts in America and Europe (e.g. Nye 2010).

One approach could be to conduct in-depth psychological studies (Vierboom/Härlen 2009, p. 24 ff.). These could include intensive surveys of three groups based on the above theories:

- People who have already experienced a power blackout lasting several days (e.g. people from the Münsterland region or from the Netherlands),
- People without any experience of a widespread power blackout and
- People involved in disaster management (managers, local emergency forces) with and without experience of a (prolonged) power blackout.

Such an approach – and also other possible methods – could provide a contribution, based on the example of a power blackout, to an analysis of human behaviour and misconduct in threat situations and the associated causes; this represents a subject that has not been widely addressed (Ungerer/Morgenroth 2001, p. 272). However, studies could also investigate whether and under what circumstances the traits of altruism and willingness to help others, which are frequently observed in disaster situations, could be strengthened in order to support the work of professional helpers (Murphy 2007).

For the members of the various aid organisations and support forces, the consequences of the power blackout will mean continuous extreme stress. The adverse circumstances, the pressure to make fast decisions even where uncertainty prevails, the many requests for assistance, the feeling of helplessness and the loss of communications structures create high levels of physical and psychological stress. Experience shows that problems are less likely to be encountered regarding dedication and loyalty on the part of helpers (e.g. Dynes 1990). On the contrary, it is likely that different organisational cultures[121] could trigger incorrect behaviour in the face of a threat and stand in the way of efficient communication and cooperation within and between the emergency forces (Drabek/McEntire 2002; see also Drabek 2010; Lasogga/Gasch 2008, p. 403 ff.). Conflicts could therefore also arise between helpers during major emergencies where very different groups such as the police, fire service, rescue organisations, the THW and psycho-social emergency assistants are brought together (Lasogga/Gasch 2008, p. 142).

Prejudices and barriers to communication are especially prevalent if emergency forces do not know each other. Conversely, there are numerous indications that obstructions can be reduced if the relevant parties obtain a better mutual understanding of each others' respective tasks and roles by ensuring local proximity, joint exercises or operational experience. Research efforts are also required into these aspects. The factors that promote and hamper communication should be further clarified by conducting more intensive socio-scientific and interdisciplinary analyses.

121 These include different objectives, concepts, languages, hierarchies and management styles.

VULNERABILITY, OPTIONS FOR COPING AND NEED FOR ACTION – CONCLUSIONS IV.

Chapter II above described the German system for crisis management, while Chapter III then described the consequences of a power blackout for seven selected sectors (Chapter III.2.2). This chapter now provides a conclusion. It brings together the statements made in the respective sector analyses in order to assess the vulnerability of these sectors and also the opportunities available to and the limits of disaster management (Chapter IV.1 to IV.7). These sector-specific observations are followed by cross-sector conclusions (Chapters IV.8 to IV.13). In each case, statements are made concerning the need for information and research and also on possible action.

INFORMATION TECHNOLOGY AND TELECOMMUNICATIONS 1.

A power blackout has a huge detrimental impact on the »information technology and telecommunications« (IT/TC) sector. After just a short time it is no longer possible to use fixed-network and mobile telephony or indeed the Internet and in some cases it is not possible to receive radio broadcasts. Even satellite-based telephones can only be used while the end terminals' energy-storage devices are still functioning. It is only possible to dial into mobile phone networks on the edges of the area affected by the power blackout. Even in the first few days it becomes clear that telecommunications suppliers are unable to provide the minimum level of telecommunications services that are planned for a disaster situation and required by law. The reserve capacities such as UPS and emergency power generators that are kept for key communications facilities are exhausted after a few hours or days or become unusable because end terminals are no longer working.

VULNERABILITY AND COPING CAPACITIES

Although individual infrastructure elements (e.g. terminals, networks, switching centres) in the various sub-sectors are able to bridge a certain period of time, these are not harmonised with each other and the resilience of an infrastructure therefore depends on its weakest element.

In the field of fixed-network telephony, trunk exchanges have emergency power capacities designed to last up to a few days, but these prove ineffective because the subordinate switching centres and terminals stop working.

- By contrast, mobile phone terminals could be used for several days and even up to a few weeks with corresponding usage and even central switching stations could still operate for a few days. The weak point in this infrastructure is set by the base stations which – due to the increased volume of calls – can only continue to work for a few minutes or hours.
- Satellite telephony is far more resilient, and depending on capacity and usage of terminals can enable communication for hours or days. However, satellite telephones are not very widely used and are thus of minor importance in terms of maintaining general communications.
- The Internet is operated via the well-protected remote transmission network. However, because the end devices and access devices are powered by electricity, dial-in is only possible to a limited degree and at most for only a short period if mobile computers or smart phones can dial in to local switching centres or base stations that are still working.
- With their legal mandate to provide emergency communication and information, radio broadcasting corporations have contingency preparations in place and can continue to work for several days. However, televisions stop working immediately, and (battery) operated radios represent the only remaining option in terms of receiving devices. The millions of radios in circulation can in principle continue to work and receive broadcasts for hours or weeks (e.g. car radio).
- Despite the presence of emergency power generators in printing shops, logistical challenges and restrictions in terms of editorial work mean print media can only be used to a limited degree for information and communication purposes.

Within a very short time, therefore, the public is deprived of the ability to engage in active and dialogue-based communication by telephone and the Internet. The network structure of many electrically driven network routers, switching exchanges and radio antennae for fixed and mobile telephony and also the Internet makes it almost impossible to ensure wide-scale reconnection because thousands of battery storage units would have to be charged and fuel tanks supplied. At most, it is conceivable that partial reactivation of individual infrastructure elements would be possible at the edges of the area affected by the power blackout. Moreover, the failure of communications infrastructures also affects the authorities and task forces, who use the remaining communications capabilities on a priority basis.

NEED FOR INFORMATION AND PROSPECTS FOR ACTION

It would appear that in economic and technical terms, it is not possible to ensure sustained safeguarding of communications networks that makes it possible to maintain a stable, extensive offering of services for the public. As far as can be seen, concepts that offer at least a defined minimum level of supply in the event of a prolonged power blackout have not yet been developed. In this context, extensive and detailed information is required on the existing coping capacities of authorities and private companies. Overall, there is a lack of relevant data and specific vulnerability analyses for the sector. Chapters IV.4.10 and IV.4.11 include a discussion on the need for further research.

TRANSPORT AND TRAFFIC 2.

In the »transport and traffic« sector, electrically powered elements of the transport modes road, rail, air and water stop working immediately or after a few hours. Numerous accidents, traffic jams, stranded trains and underground trains, diverted flights and logjams of lorries and goods in ports create major restrictions for individual mobility and for goods transport, and therefore for supplies for the population. A prolonged power blackout – and thus an extensive blockage of traffic modes and traffic flows – would have menacing consequences for Germany in its capacity as a transit country, a production location and an exporter (BBK 2008a, p. 18).

VULNERABILITY AND COPING CAPACITIES

In the first few hours after the power blackout in particular, the authorities and aid organisations encounter growing problems in major cities and conurbations. Fire-fighting, emergency rescues and missions to ensure emergency power supplies and a number of additional measures to manage the general damage situation are significantly hampered. Almost all petrol stations are out of action. In addition, the increasing problems in the field of telephony are making themselves more apparent. There is also a threat of major bottlenecks in supplying the population with, for example, food or medical requisites.

The authorities are thus faced with complex challenges. At local level, it is necessary to ensure an adequate supply of fuel for task forces and for the emergency generators of particularly sensitive critical infrastructure components (such as control centres, BOS, hospitals). In addition, it is necessary to clear, block off and impose traffic bans for important routes to ensure they are made clear and also kept clear for the emergency task forces. Finally, it is necessary to establish (interregional) transport axes and to make transport capacities available in order to ensure the supply of essential goods.

The systems of the different transport modes must at least be restored in such a way as to ensure that the infrastructure requirements for reaching the required destinations are in place. Here, there are considerable differences in terms of resilience and coping capacities.

In the roads sub-sector, roads and track systems in major cities and densely populated areas must be cleared to enable the vehicles of the emergency forces to reach locations where they are needed to carry out tasks. Buses are used in an attempt to ensure rudimentary local public transport. Motorways and highways can be used as transport axes. Within and outside the area affected by the power blackout, lorries and buses can be used on the basis of the Traffic Services Act (VerkLG) to carry out supply and evacuation operations.

In the rail sub-sector, available emergency forces and rail staff are widely used in the first few hours in a bid to evacuate underground trains and stranded passenger trains and also to clear railway stations and care for the people involved. Capacities of the fire services, the THW and the police are deployed. A few hours after the start of the power blackout the first diesel locomotives can be used to recover stranded trains. Heatable points components cannot be kept free of frost in the winter and are bolted down. Railway control centres and points have to be operated manually by rail staff. Shunt yards are also likely to have increased staffing requirements.

Pressures of time and the adverse circumstances mean huge stresses for helpers, and also for rail staff in the shunt yards, control centres and for those working with control and safety technology. Symptoms of stress and exhaustion can in particular be expected after a few days/a week. The breakdown of communications structures means almost insurmountable difficulties are encountered in co-ordinating measures and the task forces.

Rail transport is of crucial importance in terms of ensuring supplies for the public. Once tracks have been cleared and points bolted down, key stretches of the rail network can be made passable and diesel trains can be used on these routes to transport larger volumes of goods and people. During the power blackout the relevant authorities must work with the rail operators to decide on routes and measures that will enable emergency operations.[122]

In the air sector, airports prove relatively resilient because of their extensive emergency power supplies. Some scheduled take-offs and landings can still be processed, but some flight movements are prohibited (EBP 2010, p. 22). Once it becomes clear that the power blackout will last for some time the crisis units adapt their plans and measures to the new underlying conditions. Air-traffic control and aviation companies divert flights and start to re-plan. The main priority is then to look after all passengers who are still waiting, to maintain ground operations and to ensure airport security. In addition, the question of to what extent supply flights are possible (where applicable as visual flights) is examined.

122 DB AG has set up the DB situation centre as an »operational instrument and organisational tool for crisis units and work forces« (BBK 2008a, p. 122).

In the sub-sector of water, problems mount at sea and inland ports and operations come to a virtual standstill. The respective port authorities implement their emergency plans and endeavour to reduce port operations, clear traffic jams and make contact with ships and the competent authorities. During the power blackout the police are unable to perform any security tasks for port facilities. The fire service and the Federal Agency for Technical Relief (THW) are used where necessary, e.g. to establish a power supply using mobile generators or if dangerous situations arise in connection with hazardous goods.

Once it becomes clear that the power blackout will last for some time, attempts are made to divert arriving or scheduled goods traffic and for such traffic to be handled by road and rail. This requires agreements between the competent departments and the companies and also with ports in Germany and Europe that are not affected by the blackout. This can present major difficulties given the breakdowns in information and communications technology.

WATER AND WASTEWATER 3.

Water infrastructure systems cannot be operated on a long-term basis without an available electricity supply. In the same way as the water supply system, so wastewater disposal uses electric pumps at key points within the system. The consequences of these pumps being out of action for a long period would be catastrophic, especially as regards supplying the public with drinking water. Also, if a power blackout lasts for a long time, fire-fighting water is likely to become so scarce in cities that it becomes impossible to ensure effective prevention of fires and fire cascades.

VULNERABILITY AND COPING CAPACITIES

As shown by the analyses of the direct and indirect consequences of a power blackout for water infrastructure systems, the current available structures and technologies used for water supply and wastewater disposal would mean having to resort almost entirely to makeshift solutions that are highly complex in terms of the personnel, organisation, time and materials required. This includes providing supplies to the public through the use of emergency wells and the use of tankers and mobile toilet trailers. Additional measures include maintaining the supply and disposal networks at a low level of operating performance by bridging measures and by functional replacement of individual components and facilities that are dependent on the power supply. This especially requires the use of mobile emergency power generators. As they are probably only available in small numbers, they would have to be used at alternating locations (e.g. at water works[123] or lift systems in the sewage system). It would also be necessary to flush the sewage networks, e.g. using water from tankers.

NEED FOR INFORMATION AND PROSPECTS FOR ACTION

Since Germany currently needs high volumes of investment in order to maintain, restore and rebuild its water infrastructure systems, this provides an opportunity to consider vulnerability and resilience factors when planning and designing future systems and to create synergies designed to ensure systematic solutions for disaster situations.

Synergies are, for example, possible with wastewater treatment plants. Intensive research and development work is already being conducted with a view to increasing energy efficiency and autonomous energy production through the conversion of biogas into electricity at cogeneration power stations; this work is also driven by financial considerations (MUFV Rh-Pf. 2007; UBA 2008). Based on the current state of the art, further expansion of the conversion of biogas into electricity at cogeneration power stations and a simultaneous increase in energy efficiency would make an autonomous energy supply a conceivable option (UBA 2008). Currently, large sewage plants that use this technology have a self-sufficient energy supply rate of between 25 and 30 %. However, the power generation plants cannot easily be used for isolated network operation.[124]. Isolated network compatibility requires power electronics that enable an isolated micro network (individual plants or even groups of houses) to be supplied via decentralised systems (Chapter IV.12).

In a disaster situation, energy self-sufficiency through autonomous energy production and isolated network compatibility of decentralised power generators would help ensure supplies after a power blackout. Such systems could aim to enable sewage treatment plants to work safely and simply on an autonomous basis without having to implement costly improvisation measures or commit staff and mobile resources. As a central part of the infrastructure, water works should also aim to achieve this objective by becoming integrated in a supply structure that offers isolated network compatibility.

A less extensive option for disaster management involves the introduction of energy-saving minimal operation for the water infrastructure. The operators surveyed during the TAB project hope to introduce this type of operation. Min-

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123 Although water works often have their own emergency power generators or have access to generators owned by, for example, municipal utilities or the local authorities, it is questionable whether these are actually available when required and whether it is possible for the switchover to emergency operation (which may be hampered by transport problems or competition for emergency power generators) to proceed smoothly.

124 In Baden-Württemberg around 40 % of sewage plants that are operated by means of a cogeneration plant can also work independently of the power grid (Keicher et al. 2008).

imal operation must be based on available resources and must combine and use the existing infrastructure elements to optimum effect, e.g. by switching off parallel water treatment process lines in sewage plants in order to save energy or through mobile and flexible use of emergency power generators at lifting systems in the sewage network.

Among other things, this could have the following implications for private households:

- Water supplied at a reduced pressure, water doesn't reach upper storeys;
- Supply focuses on selected parts of the supply network;
- Reduced quality of water supply to ensure faecal transport from homes and to the sewage system is still guaranteed, but food-quality water can only be achieved by consumers carrying out further processing (e.g. disinfection).

Finally, there is still a considerable need for improvements to simple (i.e. not system-based) safety concepts for sewage plants, for example. For Baden-Württemberg, Keicher et al. (2008) identify considerable residual potential for equipping systems with an uninterruptible power supply, for stocking operating resources (e.g. diesel) for emergency power generators (supplies are generally only enough for 24 hours) and also for drawing up emergency plans that help set necessary priorities.

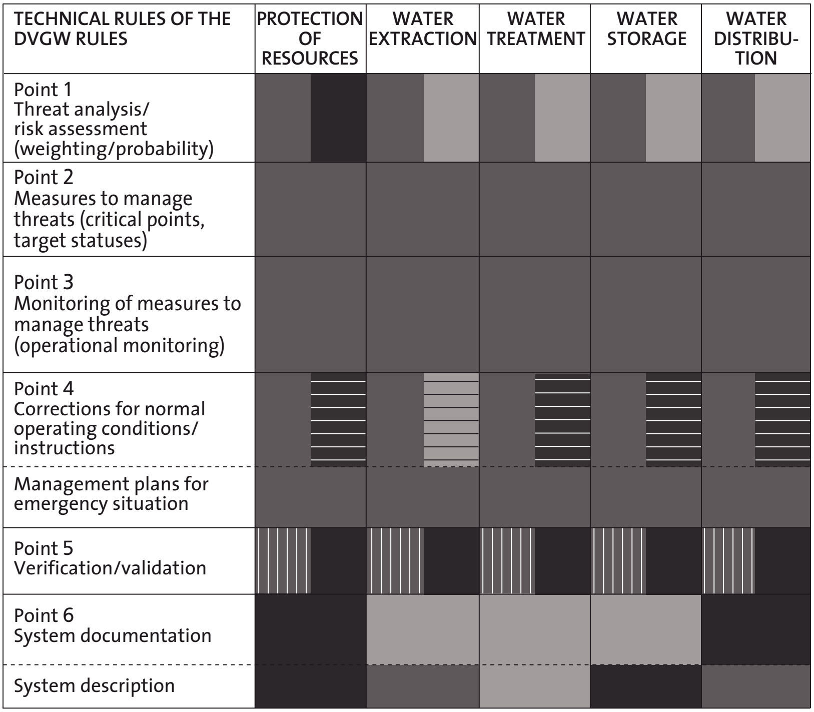
The field of fire protection offers opportunities for reducing vulnerability – for example by developing and using new technologies that reduce water requirements through more effective use of fire-fighting water. These include mobile high-pressure extinguishing systems on board fire engines and stationary extinguishing systems in apartment blocks, office buildings and industrial facilities (e.g. high-pressure extinguishing systems that use a fine mist of water to cool and smother the fire at the same time). These can be powered by an emergency power supply or using gas from pressurised cylinders and require small-volume water tanks in the buildings. In terms of the size of the water infrastructure, these systems represent an improvement in terms of costs and efficiency and are currently the focus of research.

In view of the overriding importance of water infrastructure systems, greater consideration should be given to measures to improve their resilience. The aforementioned system-based and non-system-based approaches could make useful contributions towards improving the resilience of the water supply in the event of a prolonged power blackout.

SAFETY CONCEPTS, RESEARCH ON VULNERABILITY

In 2004 the WHO published new guidelines on drinking water quality and recommended the drafting of a drinking water safety concept (Water Safety Plan) to guarantee drinking water quality. This includes comprehensive risk assessment and management approaches covering all stages from water extraction to delivery (WHO 2009).

FIGURE 26 ELEMENTS OF A DRINKING WATER SAFETY PLAN IN SELECTED PARTS OF THE DVGW TECHNICAL RULES



The findings were analysed using the following three categories

- Exists/regulated, minor addition required where applicable
- Partially exists, additions required
- Hardly exists/inexistent, extensive additions required
- Requirement for technical rules questioned
- In Germany, regulated through statutory requirements (e.g. Drinking Water Ordinance, TrinkwV)

Source: Bethmann et al. 2006

Bethmann et al. (2006) demonstrate that the DVGW technical rules already include key elements of the WHO water safety plan. Figure 26 provides a graphical overview. However, the graphical illustration also shows that the issue of risk assessment is hardly implemented in the fields of water extraction, water treatment, water storage and water distribution. Here, there is a need for extensive augmentation because priorities for developing measures can only be set on the basis of risk assessments.

Among other things, methods based on simulation models are used to conduct risk and vulnerability analyses for major technical systems such as water infrastructure systems. Frequently considered threats include contamination of drinking water and malfunctions of individual components or system components (caused either by deliberate actions, accidents or by natural events). The consequences of a prolonged power blackout on the water infrastructure have not yet been investigated on the basis of models. In the field of infrastructure systems, modelling is used at different levels of detail and with different objectives and perspectives (e.g. the analysis of probabilities of occurrence and the simulation of damaging events and their spread). Subjects used for the models include, for example, relevant physical processes such as hydraulic processes in pipeline systems. Models of this type are often used to answer very specific technical questions relating to optimising operations or planning. Technically detailed models of the water supply infrastructure include EPANET, a software development by the USA Environmental Protection Agency which aims to improve the water supply. EPANET is also used in a series of publications as a basis for vulnerability analyses that consider various threat situations. For example, Navarro-Roa et al. (2008) conduct probabilistic defect analyses by simulating malfunctions of individual technical elements. Tidwell et al. (2005) and Thompson et al. (2007) analyse the threats that can result when water is contaminated.

However, abstract models that consider the water infrastructure system as part of a mesh of interacting infrastructures (»system of systems«) are also used. These models are based on approaches that focus on the links between the individual infrastructure systems and their input and output factors. The importance of this system-of-systems approach is emphasised by Kröger (2008), who also deduces a need for new modelling methods suited to this purpose. The resulting gain in knowledge concerning the mutual dependencies between infrastructures could prove useful when developing a preventive disaster management system (Dombrowsky 2007).

FOOD SUPPLY 4.

The food sector is characterised by a high level of vulnerability. Within a week, plant production and animal husbandry suffer considerable damage. In particular, it can be expected that even during the first 2 days, the supply chain from retail food warehouses to branches and thus to consumers is severely disrupted and collapses soon after. Since all data lines have stopped working, there is no flow of information available to enable operators to respond to local needs and to arrange deliveries where they are required.

VULNERABILITY AND COPING CAPACITIES

Supplying the population with food is one of the key functions of the critical infrastructure system; indeed, it is vital for survival (BSI 2005, p. 137). In a disaster situation, ensuring the supply of food forms part of the state's duty of protection pursuant to Article 2 [2] clause 1 of the Basic Law (GG).

As part of their disaster management endeavours, the authorities can – sometimes working in conjunction with the retail trade – take the following measures, among others:

- The rationed release of stocks of the »civil emergency reserve« and of the »federal reserve of grain« is initiated on the basis of the Emergency Food Supply Act. The »federal reserve of grain« stores grain such as wheat and oats, while the »civil emergency reserve« stores rice, pulses, milk powder and condensed milk. Where possible, these undergo further processing and are handed out via collective care centres (BLE 2006, p. 3 and 7). The Traffic Services Act (VerkLG) is used to counter logistics problems faced in distributing the reserve stocks by adding extra transport capacities. In addition to these measures, the retail sector starts intensive interregional efforts to supply the affected region (BMELV 2005, p. 71). Where food is able to be delivered, some sales are conducted directly from lorries in front of branches (BMELV 2005, p. 120).
- Food handout centres are set up in selected retail food branches. These are equipped with emergency power generators and are where possible given consideration during the allocation of fuel. The corresponding companies in areas of Germany that are not affected or in other countries coordinate the required logistics processes in consultation with the authorities.
- Since most people have no facilities to prepare hot meals, large canteens are for example set up by the THW, the German Red Cross (DRK) and the Federal Armed Forces or hot meals are handed out.

Nevertheless, stocks of food in households and in branches and warehouses of the food trade sector could dry up by the end of the first week in the area affected by the power blackout. The possibility of also resorting to German stocks of the EU intervention reserve is therefore considered. This includes cereals, rice, olive oil and table olives, milk and milk products, beef, pork, lamb and goat meat. The question of requesting stocks from other EU states could also be considered. However, since large quantities of the warehoused goods (e.g. barley) can only be used to a limited degree for food and the goods are not generally stored in the vicinity of production locations, this option is rejected (Rasche et al. 2001, p. 63).

Despite best efforts, however, it is highly probable that it will not be possible to ensure a satisfactory extensive supply of food to meet requirements. The main obstacles are likely to be the fact that the various players are poorly networked in some cases and also the lack of means of communication. No uniform picture of the situation is available, making interregional coordination of measures extremely difficult.

NEED FOR INFORMATION, PROSPECTS FOR ACTION

Assuming that the above observations are accepted, key starting points for improving the resilience of the sector could in particular include the regional central warehouses of the retail trade and also in some cases selected branches. These could be equipped with a resilient emergency power supply. The question of agreements with the petroleum trade to ensure deliveries for the emergency power generators could, for example, be considered. If power supply points are available this would enable the use of mobile generators (by electricity supply companies, the THW and the Federal Armed Forces where applicable), although their long-term use would have to be ensured.

More far-reaching concepts along the lines of a public-private security partnership could be examined. For example, efforts could be made to reach an agreement with the retail trade specifying the provision of one branch outlet suitable for coping with disasters for every 10,000 inhabitants and also specifying the provision, in every federal state, of a food warehouse that is equipped with an extensive storage facility, means of communication and emergency power generators. These would be recorded in a central database, which could be used by authorities and companies to coordinate deliveries in the event of a disaster.

The specific conditions of a power blackout also make it necessary to consider if the type of food stockpiled by the state and also the planned processing and distribution of such foodstuffs are appropriate to the situation. For example, it may not be possible to produce flour in mills. Also, private households do not have sources of heat to prepare food. Aspects such as these should therefore be included in current reflections on how to improve provisioning.

Another possible course of action would be for the retail trade's central warehouses to have an autonomous power supply based on renewable energies, thus permitting a high level of self-sufficiency. Since central warehouses have a large roof area and are generally located on the outskirts of or outside towns, it would be possible to use renewable energy sources such as solar power and wind power and to use corresponding storage technologies, provided thorough planning was carried out; cogeneration diesel generators could also be used.

Since it has been shown that a large number of animals would not only suffer harm but would in many cases also die in the event of a power blackout, steps should be taken to examine whether legislative provisions (e.g. the Animal Welfare Livestock Husbandry Ordinance, TierSchNutzVO) could include more precise requirements on emergency power supplies and an associated obligation to store fuel to operate emergency power generators.

HEALTH SECTOR 5.

This sector is organised on a decentralised basis with a strong emphasis on the division of labour; this factor and also its lack of adequate protection through an emergency power supply means that after just a few days, it is unable to cope with managing the consequences of the power blackout. Alongside the increasing exhaustion of internal capacities, the efficiency of the health sector is also reduced by the impairment of other critical infrastructure functions. In particular, shortages in the supply of energy, food, communications, water and transport services exacerbate the declines in terms of the scope and quality of medical care. By the end of the first week at the latest there would be a high probability of damage to the health of, a threat to or the death of very large numbers of people; moreover, it is unlikely that the problem situation could be overcome by relying solely on locally/regionally available resources and personnel capacities.

VULNERABILITY AND COPING CAPACITIES

The internal (especially material) capacities of the regional health system are largely exhausted within the first week. There is a lack of insulin, blood supplies, blood products, sterile products and fresh linen. Measures such as isolated blood donation campaigns or the treatment of laundry in field laundries are unable to adequately cover demand. It also becomes increasingly impossible to supply medications because stocks at hospital pharmacies are used up[125] and manufacturers and the trade sector are unable to effect deliveries to meet requirements. It is also not possible to guarantee the supply of special products (e.g. special diets) required by certain patient groups or to guarantee the supply of suitable products for dialysis patients. This increases the mortality rate considerably.

125 According to the Ordinance on the Operation of Pharmacies, hospital pharmacies must keep sufficient supplies to meet the average 14-day demand for drugs and medicine products. In principle, they should also be able to produce drugs themselves. This is not universally guaranteed due to scarce financial resources or a lack of storage space. In some federal Länder hospital pharmacies designated by the state health authorities are responsible for managing and issuing basic drugs in the event of disaster situations (Paul/Ufer 2009, p. 165).

Some hospitals can maintain a minimum level of operations and thus become central hubs within the medical care network. They still have a certain but dwindling stock of medicines and also sufficient staff and fuel. However, this relatively good situation also means that when other establishments have to be evacuated, their patients are sent to these hospitals. As a result, the hospitals face self-perpetuating problems: on the one hand dwindling reserves and an extensive loss of specialised units, and on the other hand an increasing overload on existing capacities due to the rising occupancy levels. It is difficult to defuse the situation by discharging patients as this is only acceptable for patients who can look after themselves. Increasing problems are encountered with the drinking water supply and it becomes necessary to resort to emergency wells.[126] However, transporting the water to hospitals and nursing homes proves problematic (Geier et al. 2009, p. 76).

Some old people's homes and nursing homes are still able to provide a basic level of care with the assistance of aid organisations (e.g. an adequate supply of food and clean linen). However it is not possible to provide more extensive care for patients requiring medical care. Additional overload symptoms manifest themselves through increased enquiries from individuals who are cared for at home.

Although the emergency medical services can still be used to a limited degree for transport and evacuation operations and the THW and fire services can replace/provide infrastructures such as power generators or pumps at many locations, the disruptions to the communications infrastructure mean the emergency medical services are largely unable to receive emergency calls from the public or only receive such calls following significant delays. This has a huge detrimental impact on pre-clinical medical care.

At the end of the first week the sector's basic infrastructure services have come to a virtual standstill as a result of the power blackout. For example, most doctors' surgeries and pharmacies are unable to operate and can no longer fulfil their role as a distributor of medicines due to the dwindling supplies. Dialysis centres are closed, patients and remaining treatment capacities have been transferred to hospitals. The production and sale of pharmaceutical products has come to a complete halt in the area affected by the power blackout. The disaster protection laws of the Länder do not make explicit provision for the participation of manufacturers and the retail trade in disaster control and such participation is only anchored in a few hospital alarm and emergency plans. There is therefore a need to conclude agreements on production and logistics with representatives of manufacturers and the retail trade.

126 In the 1970s emphasis was placed on establishing these in the vicinity of hospitals and nursing homes (Geier et al. 2009, p. 75; see also Chapter III.2.3.4).

At best, first aid services by the Federal Armed Forces within the framework of »civil-military cooperation« provide only sporadic relief (Ackermann et al. 2009a, p. 71; Wagner 2009a, p. 407 and 2009b, p. XXXVI). The collapse of medical care focussed in hospitals is imminent.

If one imagines a scenario where the developments and situations that have emerged by the end of the first week continue for even longer, it can be seen that it would be virtually impossible to guarantee the health sector's key function of supplying people with the necessary medical services. The risks for life and limb would rise exponentially, and the state as a whole would be unable to fulfil its duty of protection. Without any external input of medical goods, infrastructures and specialist personnel it is no longer possible to provide medico-pharmaceutical care.

NEED FOR INFORMATION, PROSPECTS FOR ACTION

Hospitals play a key role as anchor points for medical care of the public. Although they do exhibit a certain level of resilience, this is not sufficient to compensate for the loss of all other facilities – especially decentralised outpatient care. If diesel generators are made available to provide an emergency power supply it is necessary to guarantee continuous replenishments of fuel. To a limited extent, this requires the storage of fuel on-site or agreements with suppliers (who would probably find it difficult to effect deliveries because of the general consequences associated with the power blackout).

In principle, supply points for an emergency power supply need to be included in plans for new hospital buildings. Ultimately, hospitals should be defined as having priority entitlement in terms of the allocation of fuel by the disaster control authorities. A more far-reaching approach is to ensure the highest possible level of energy self-sufficiency and isolated network capability; work on this has already been started in many hospitals within the context of environmental protection efforts and measures to reduce energy consumption. Possibilities for treating water/transporting water from emergency wells to hospitals/emergency hospitals should be examined in greater depth in order to ensure the supply of drinking water to hospitals (Schutzkommission 2006, p. 83).

The current underlying economic and political conditions are not entirely conducive to improving provisioning in hospitals. However, the sector analysis has demonstrated that this could play a major role in improving resilience. Another option worthy of consideration is the inclusion of more extensive derogations in the Pharmaceuticals Act to accommodate disasters and emergencies. The aim must be to ensure practical regulations for supplying the public in a prolonged disaster situation (Paul/Ufer 2009, p. 157 ff.).

Another option could be to include manufacturers and the retail trade and also pharmacies in disaster management. Here, it would be necessary to ensure that all the aforementioned players take precautions to ensure manufacture and distribution in the event of a prolonged power blackout. In view of the general reduction in stocks kept and sophisticated just-in-time logistics, it is necessary to examine what economic consequences this could entail and in which legal form this could be implemented.

FINANCIAL SERVICES 6.

Whereas payment transactions and data traffic of banks and also stock-market trading activities prove relatively resilient even during a power blackout, banking services for customers soon threaten to collapse due to the failure of communication paths.

VULNERABILITY AND COPING CAPACITIES

Customers are unable to conduct transactions with their banks via telephone or the Internet. Banks cannot issue cash from cash dispensers and customers are unable to make cashless payments in shops. Demand for cash will therefore rise quickly, not least because people in Germany apparently only carry 118 euros on them (Deutsche Bundesbank 2009 b, p. 40). Despite an initial calmness, the immediate breakdown in the supply of cash via cash dispensers and subsequently at bank counters and also the collapse of cashless payments lead to expressions of annoyance in shops and banks and to aggressive altercations in some cases. Once it becomes clear that the power blackout will last for some time, uncertainty grows among the public. People are afraid they won't be able to get supplies of food and other daily requisites because they soon won't have any money left and won't have the option of cashless payments, either. In some cases this leads to violent altercations, theft and break-ins. The police are forced to intervene at times. Moreover, as the power blackout continues it becomes necessary to guard individual shops. Shop sales plummet. It is also not possible to rule out the possibility of prices of everyday essentials increasing even during the course of the first week. Informing customers and ensuring appropriate risk communication in consultation with the disaster control authorities thus becomes even more important.

Getting cash supplies to the population becomes a key focus. According to the German Bundesbank »special provisions have been made as part of crisis management organisation to manage an emergency or disaster« (BBK 2008a, p. 120). However, it is questionable whether sufficient supplies of cash to meet requirements can be continuously transported into a large area over a long period of time by private cash transit companies, distributed and subsequently issued by the banks.

The economy suffers due to the extensive inability of the public and companies to make cashless purchases, conduct loan negotiations, make wage payments, issue stock-market orders; it also suffers due to the liquidity shortages that soon emerge.

NEED FOR INFORMATION, PROSPECTS FOR ACTION

The consequence analyses have identified the provision of cash supplies to the public as a particular weakness. Consequently, the German Bundesbank must cooperate with other organisations and civil protection task forces and also the banks in order to ensure at least a rudimentary supply of cash for the public (EBP 2010, p. 79). To create better conditions for this, it is necessary to examine if the Bundesbank should also be included among the organisations authorised to request priority access to transport capacities pursuant to the Traffic Services Act (VerkLG). An extended logistics and security concept is probably required for disaster situations because, for example, it is not possible to ascertain whether and how private service providers could adequately safeguard higher volumes of cash deliveries.

There are plans to close numerous branches of the German Bundesbank over the next few years. Consideration should be given as whether and to what extent these cuts to the infrastructure will affect the supply of cash in a disaster situation.

»PRISONS« CASE STUDY 7.

Initially, correctional facilities are able to maintain reduced operations with the help of a functioning emergency power supply. Among other things, this makes it possible to ensure prisoners are locked up in their cells and that sufficient lighting, ventilation, heating and surveillance systems are available. Nevertheless, a significant problem overload develops after a few days: hygiene and the supply of medicines and food cannot be ensured across the board and to a sufficient degree. Unrest and aggressiveness rise among prisoners; staff experience continuous increases in stress levels.

VULNERABILITY AND COPING CAPACITIES

Fuel reserves at correctional facilities are probably only sufficient for a few days. The provision of mobile emergency power generators and the delivery of additional quantities of fuel are therefore imperative to ensure continued emergency power supplies.[127] If emergency power supplies are jeopardised, transferring prisoners to other correctional facilities outside the affected areas that have not reached their maximum occupancy rates would appear almost unavoidable. In some circumstances, occupancy capacities could, where necessary, be temporarily increased by accommodating prisoners two to a cell instead of in single cells.

Accommodating (some) prisoners on a temporary basis in suitable larger buildings (e.g. barracks) in areas with a functioning power supply could also be considered. However, this would create problems in terms of the restricted ability to control individual prisoners, and also in terms of ensuring hygiene, supplying prisoners with food and supplying the staff required to provide surveillance and care.

Even if it were possible to maintain an emergency power supply, it would probably be impossible to ensure orderly operations because the problems of ensuring supplies and of securing prisoners would be too great. If detainees flee from correctional facilities or are indeed released this can trigger major uncertainty among the public; the competent authorities and politicians with relevant responsibility would also find themselves under pressure (EBP 2010, p. 162). Depending on the situation in the individual correctional facilities, the management of the respective correctional facilities and also those responsible within the crisis units must decide whether it is appropriate to transfer the detainees and how this should be implemented. This could create huge problems in terms of coordination due to the failure of fixed-network and mobile telephone systems (Chapter IV.1). It is also doubtful whether it would be possible to call on sufficient suitable transport capacities including the necessary security personnel.

NEED FOR INFORMATION, PROSPECTS FOR ACTION

In terms of their functions, prisons are not critical in the sense of being »vital for survival«. However, if those in charge are not able to maintain operations or to evacuate the buildings in an orderly manner, this would probably considerably dent the public's confidence in the ability of state organisations to manage situations. Under no circumstances should there be any damage to the expectation that authorities are able to guarantee public safety and security. Consequently, correctional facilities are included among the buildings where corresponding contingency measures are taken to ensure a stable emergency power supply and

127 Although this can be organised prior to a power blackout by concluding contracts with relevant suppliers, it is questionable whether such delivery contracts could actually be adhered to given the other consequences of the blackout (e.g. traffic chaos, shortage of fuel, failure of fixed-network and mobile telephone systems). Consequently, the allocation of fuel by the competent crisis units/operational control centres becomes a priority task.

that should be given priority consideration as regards the allocation of emergency power systems and/or fuel.

As in other sectors, the case study on prisons was unable to definitively ascertain whether, how and for what lengths of time an emergency power supply is guaranteed. It is also uncertain whether a prolonged power blackout is an issue considered in correctional facilities' emergency plans or in alarm and emergency plans of the subordinate civil protection authority and whether corresponding exercises are organised with the involvement of external support forces. It is not possible to identify explicit statutory regulations on emergency power supplies in correctional facilities. It was not possible to clarify with certainty whether relevant standards exist at the level of administrative regulations, based on the disaster control and intervention acts of the federal Länder. In addition to this issue, there is also a need for further information and legal clarification concerning possible measures that may become necessary (e.g. non-admission of day-release prisoners or »prison leave« for selected groups of prisoners).

DISASTER MANAGEMENT ACROSS SECTORS AND ORGANISATIONS 8.

The sector analyses have shown that the consequences and chains of consequences triggered by the power blackout create a situation in which the life, physical integrity and safety/security of the population are threatened to a high level and in which major material damage occurs. Local authorities and aid organisations and also available resources are insufficient to cope with the disaster. This threat and damage situation requires the mobilisation of interregional resources to enable the state to meet its duty of protection.

LEGAL BASES

As demonstrated in Chapter II, corresponding requirements have been created by the legislator and regulator at legal and administrative level. External management capacities and an interregional joint action force can be mobilised on the basis of Article 35 of the Basic Law (GG) (administrative assistance) or on the basis of various precautionary acts in order to support regional capacities. This opens up the following options:

- Elements of the Federal Armed Forces can be mobilised within the context of »civil-military cooperation«. As well as providing personnel support (e.g. for the police, disaster control authorities, local aid organisations or health establishments), this also makes material resources available. For example, hospitals and reception centres can be equipped with camp beds and tents, large canteens can be set up or Federal Armed Forces vehicles can be used for transport and evacuation measures.

› Certain (mainly public) operators can be granted preferential access to telecommunications and postal services on the basis of the Law Concerning the Transformation of the Deutsche Bundespost Enterprises into the Legal Structure of Stock Corporation (PTSG) and a corresponding statutory instrument by the Federal Ministry of Economics and Technology (BMWi). In addition to radio and tannoy announcements, this would also enable the fixed-line and mobile phone network to be used at least on a local basis. This allows better coordination of the authorities and under certain circumstances also makes it possible to keep the public better informed.
› To safeguard food supplies, recourse can be made to the »civil emergency reserve« and the »federal reserve of grain« in accordance with the Emergency Food Supply Act (BMELV 2005, p. 95).
› Once the Federal Government has declared a special emergency situation, private companies can provide transport capacities under the Traffic Services Act (VerkLG) to support the area affected by the crisis. The Federal Office for Goods Transport undertakes preparations to make these transport capacities available to the agencies requesting assistance. To relieve the pressures on transport routes the disaster control authorities can also impose a general ban on driving. Priority can also be given to clearing corridors and transition points to regions with an intact power supply and to providing reception capacities.
› Finally, to safeguard fuel supplies, the Federal Ministry of Economics and Technology (BMWi) can issue a statutory ordinance to release stocks on the basis of the Petroleum Stockholding Act. Large quantities of fuel can then be made available via the rail network or by means of diesel-powered vehicles.

In combination with other legislation and statutory instruments at federal state level and also official implementing provisions, the necessary prerequisites for mobilising disaster management capacities have been established on a comprehensive and differentiated basis to meet specific and cross-sector requirements, especially with regard to back-up forces and resources.

At the same time and to a certain extent, this plethora of legal materials and the possibilities for action it creates appear excessively complex with little coordination. For example, the legal bases for disaster management in the »health« sector are set down in at least eleven federal and Land laws and ten statutory instruments/administrative regulations. As in other critical infrastructure sectors, it is clear that instead of a uniform legal framework, »the legal relationships of individuals and institutions in the event of disasters« are controlled by »differently structured, poorly coordinated regulations at several administrative levels« (Stober 2008, p. 44). There is therefore a temptation to agree with Unger (2008,

p. 101), who in the light of out-dated regulations and fragmented competences makes the critical observation that »our actual preparations for disasters and the corresponding legal bases are gradually drifting apart«.

For those responsible for disaster management, this makes an already difficult task even harder. The multiplicity of instruments must be used by the relevant players at the various levels in an objectively appropriate way, at the correct time and in a way that ensures all instruments are coordinated with each other. Managing such a demanding task by means of interdepartmental and cross-organisational crisis management depends heavily on all crisis units having competent specialist personnel with a common understanding of the regulations and on »foresighted judgements being made and precautions taken to ensure the laws and statutory instruments can be used at the optimum moment« (Hiete et al. 2010, C15).[128]

This very aptly described challenge will prove difficult to overcome. LÜKEX 2004 demonstrated that significant improvements are required in terms of establishing the underlying prerequisites:

- the different organisations focussing on their own professional tasks rather than considering the complex situation,
- a lack of knowledge of legal material,
- hesitance on the part of the Länder to include players at federal level and
- a lack of consideration for the psychological effects of the power blackout.

PRIVATE SECURITY PARTNERS

The task of ensuring well-coordinated emergency and crisis management is made even more complex because of the need to include relevant players from outside the authorities. Alongside the energy utility companies, these include numerous additional companies such as information and communications companies, the food industry or the security industry. When developing feasible concepts it is important to consider the plurality and heterogeneity of critical infrastructure operators and other companies and establishments. For example, there are around 1,100 service providers in the power supply sector, 6,200 suppliers and 6,900 wastewater disposal operators in the »water infrastructure systems« sector and 3,000 suppliers of telecommunications services in the »IT/TC« sector. These companies are extremely heterogeneous. Some operate at local level, others at national or international level. There are also vast differences in terms of their disaster management expertise and capacities. It can therefore be assumed that there is a need for further optimisation as regards securing private security

128 All players in the international assistance system should therefore have a command of »uniform management rules« in order »to be prepared for joint operations through regular exercises« (Schutzkommission 2006, p. 44).

partners at county and federal state level (Hiete et al. 2010, D 25) in order to improve integration of private and public disaster prevention and management. Here, it is also important to consider private security service providers, which have now established themselves as a key element in Germany's security infrastructure. They are responsible for the security of airports and railway stations and also for nuclear facilities and shopping centres. In reality, close cooperation already exists between private security services and the police (Schönbohm 2010, p. 51). Given the expected increase in the areas in which private service providers are used, there is a need to clarify the extent to which it is, in legal,[129] technical and organisational terms, possible to create conditions for a functioning security partnership between public and private operators in the event of a disaster situation.

NETWORKED DISASTER MANAGEMENT – WITHOUT A NETWORK 9.

The authorities rely on functioning communications infrastructures to enable them to ascertain a picture of the situation, to disseminate information, to organise resources and to alert and coordinate task forces. However, after just a short time the crisis units, operational control centres, aid organisations and support forces are hardly able to access public communications infrastructures (Chapter IV.1). Difficulties are encountered in alerting people and in mobilising additional support.[130] The available management capacities and the authorities' own communications networks are not designed for a prolonged power blackout. Most communications networks are based on historically evolved, different line-based networks and radio networks and can only bridge a few hours or days without electricity.

WEAKNESSES AND OPTIONS

> The communications networks of the Federation (i.e. of the IVBB or IVBV) can generally only be operated for 48 hours using emergency power generators. However, this is insufficient for functioning communication. In addition, it is important that the communications technology of the respective member institutions has the same level of safeguards. According to an initial assess-

129 »For reasons of legal certainty and in order to preserve the reservation of law«, Stober (2008, p. 49), for example, proposes augmenting the relevant sectoral laws.

130 According to Weinheimer (2008, p. 165), the permanently available fire service forces of around 8,000 people could grow to 400,000 within 5 minutes; a further 200,000 fire officers could be available within 1 hour. Of these, 60,000 would be available for interregional operations within 8 hours. However, it is doubtful whether this level of mobilisation would be possible if telecommunications infrastructures were not working.

ment, this is certainly the case for the core institutions in Bonn and Berlin, but not necessarily for all federal authorities throughout the federal territory.

- Communication by public safety authorities and organisations (BOS) is via the private BOS radio network that is, for example, used by police forces, the THW, customs authorities, disaster control authorities, fire services and rescue services. It is based on relay stations (automatic radio stations generally sited at exposed locations) that enable transmission over large distances. Due to the out-dated technology, shortage of channels and the lack of or weak encoding facilities for analogue radio, a digital radio network is being introduced for the BOS radio network; this project is currently underway and will continue until 2012. The system is based on the TETRA 25 standard. The digital radio network in Germany will essentially comprise around 4,300 base stations and a core network with 62 transmission stations (Hiete et al. 2010). The first sections and sub-sections of the network have already been constructed. However, in terms of dependence on a power supply, the modernisation of the BOS radio network means greater vulnerability in the event of a power blackout. Whereas the BOS analogue relay stations had an emergency power supply of 4 to 8 hours, the base stations of the new TETRA system are only designed to allow battery-based bridging of 2 hours (Hiete et al. 2010, F 30).
- Comparable problems are encountered when mobilising members of the Federal Armed Forces. They use the digital TETRAPOL radio network, which is based on a cellular system and allows mobile voice and data communications. This is not directly compatible with the digital BOS radio network, and must instead be connected via transmission stations. However, since the Federal Armed Forces are unlikely to be deployed until after a few days, the BOS radio network will no longer be functioning by the time they are deployed. Presumably, this will also apply to the TETRAPOL systems. It is also questionable whether sufficient terminals are available for integrating civil task forces.
- Crisis units at local level also have the option of using mobile radio stations that are not dependent on the power supply network. The telecommunications companies and also the THW and the Federal Armed Forces have alternative network equipment that enables them to establish voice and data services in the event of a crisis and to supply them via emergency generators. This equipment includes, for example, mobile directional antennae which are also compatible with W-LAN and ISDN where necessary. However, the relevant capacities of the THW are limited and are not designed to establish voice and data services in a large region for a large circle of users. They are primarily intended for communication by the crisis units and operations control centres. The capacities of the telecommunications companies are not known. Moreover, logistics problems are likely to be encountered in making such systems available. Even if it did prove possible to establish a substitute network

early on, the batteries of the terminals would need replacing or charging on a regular basis.[131]

› Other possible options in the event of a power blackout include the establishment of temporary field cable networks, assistance by amateur radio operators pursuant to Section 2 [2] of the Law Concerning Amateur Radio Service and recourse to satellite communications. Communication by means of field cables is based on mobile power generators, which have to be supplied with fuel after a short time. By contrast, amateur radio equipment has extremely low energy requirements. Amateur radio is practised independently of an existing –electricity-based –radio infrastructure. Customary radios can be operated by means of batteries, car batteries or solar cells, even over long distances. Satellite telephony and satellite-based Internet connection also offer sufficient transmission routes, provided the required terrestrial elements (e.g. the ground stations) have a power supply. However, establishing connections between the different satellite networks could prove problematic as these interfaces are generally reliant on terrestrial facilities.

A major problem, however, is the issue of charging and replacement of radio and satellite telephone batteries. The extent to which these fall-back solutions can actually be used in the event of a power blackout is therefore questionable.

The authorities still have the option of restoring individual infrastructures on a selective basis. One possibility is to supply mobile communications base stations and the corresponding mobile services switching centre (MSC) with emergency power/fuel on at least an hourly basis. Provided a connecting chain can be established via additional MSCs, it would be possible to establish connections between users within range and also in the area not affected by the power blackout. With the additional use of pagers this would at least enable rudimentary local coordination of assistance measures. However, it is important not to underestimate the challenges of enabling a permanent supply for these infrastructures and also of the networking with other MSCs within and outside the area affected by the power blackout.

From these observations it follows that at a technical level, there is a lack of feasible short-term approaches for improving this sector's resilience in terms of disaster management. Significant expense would be required to prepare the existing public and official communications infrastructures for a prolonged and widespread power blackout. Due to the network structure of the system, it is generally impossible to use selective upgrading to make the system able to withstand a power blackout, not least because widespread communication and coordination is dependent on

131 Based on the information provided by various manufacturers and depending on the intensity of use, standard/high-performance batteries can be expected to provide between 12 to 16/18 to 26 hours of use.

end terminals being in working order. Once again, the terminal batteries prove problematic because they need to be regularly recharged or replaced within the area affected by the power blackout.

Local conditions and available resources and also the subjective opinion of the individuals with local responsibility will determine which technical solution is implemented in each individual case. Consequently and due to the pressure to act, there is a risk that although individual infrastructure elements such as radio transmitters or mobile phone stations will be restored to working capacity in many places, these will remain isolated and would not be networked to form an extensive comprehensive communications infrastructure. Achieving this requires a well-planned and coordinated process. Priority institutions and where applicable core operating times need to be specified in order to enable the establishment of a network (e.g. consisting of mobile phone stations) even where resources are scarce and thus to enable communication within the area affected by the power blackout. It is also necessary to establish when resources should be used for radio relay communications or whether, for example, preference should be given to pagers. Based on available capacities, this could enable an established core network to be expanded to form an infrastructure that was able to function at least at regional level.

Overall, it can be assumed that despite intensive efforts to restore communications infrastructures, it is not possible to establish a uniform picture of the situation. The technical options that are feasible tend to be improvised and of a short range and duration; supply proves problematic and it is likely that forces and measures can only be coordinated to an unsatisfactory degree. A special challenge faced when dealing with a damage scenario such as an interregional power blackout is that units from outside the area often have to be drafted in over long distances. Establishing technical and geographical operations sections and command posts is not possible without adequate means of communication (Rechenbach 2005, p. 200). In combination, these reasons mean disaster management by the authorities will continue to show major shortcomings.

PROSPECTS FOR INFORMATION AND ACTION

The above assessment and also the assessment contained in Chapter IV.1 concerning the vulnerability and coping capacities of the »information technology and telecommunications« sector in the event of a prolonged, widespread power blackout involve numerous uncertainties. There is therefore a clear need for further information and research.

› In principle, it is necessary to assess the minimum level of communication for the underlying case; this would then make it possible to determine the technical requirements for various levels of supply. Corresponding sub-questions would include an estimate of customary communications and data flows and also the ascertainment of existing redundancies and network segments and nodes that are critical for operations. These efforts would aim to obtain a quantitative estimate of the level of supply with communications services in the event of a power blackout after a few hours, days and weeks.

- In addition, existing concepts for emergency power supplies in the field of information technology and communications infrastructures could be reviewed and new, improved approaches developed. In this context, it would be necessary to prepare an overview of emergency power supplies for the various communications networks and services and also of their components and players. The same applies for the capacities and possible uses of telecommunications emergency power systems that can be used on a mobile basis and that have to be supplied with emergency power. This would make it possible to specify the underlying technical requirements necessary for a crisis communications network that is reduced to major cities and central nodal points.
- It would also be possible to examine possible adjustments to the precautionary measures prescribed by law. Such legal/scientific analyses should aim to identify approaches for increasing the resilience of the »information technology and telecommunications sector« in the event of a power blackout. A survey and assessment of the relevant legal bases applicable to a prolonged power blackout and an examination of the need for adjustment should also include the little-considered field of the Internet and telemedia and multimedia services. This would provide a basis for specifying in concrete terms the need for changes regarding the requirements for telecommunications providers to ensure an »adequate« supply.
- Finally, it is important to mention forward-looking analyses of the framework conditions for the sector. These should consider technological innovations (»intelligent« networks, electro-mobility) and also political (liberalisation, privatisation and deregulation), economic (diversity of competing suppliers, rapid product change) or socio-cultural changes (such as changes in forms of communication and media usage among the population). Here, it is necessary to investigate which technical developments tend to lead to an increase/decrease in dependence on (grid-based) power and which research and development processes could be furthered in order to develop information and telecommunications applications that are less heavily reliant on the power grid.

CRISIS COMMUNICATIONS WITHOUT POWER 10.

The failures in the »information technology and telecommunications« sector make it virtually impossible to maintain dialogue-based crisis communication between the authorities and the public. Since the rudimentary remaining or restored communications facilities are used by the authorities for direct rectification of damage and disaster control, informing members of the public and communicating with them is mainly restricted to local battery-based alert systems (e.g. sirens that enable voice announcements), radio announcements, distribution of flyers, personal contacts and news transmitted by means of sound trucks. Radio transmitters have a certain capacity in terms of emergency power supply. As they are also suited to broadcasting warning messages and information via the Federal Government's satellite-based warning system (SatWaS)[132], the authorities endeavour to supply selected broadcasting stations with fuel in order to ensure a means of communication during the crisis. Experience has shown that established reception centres such as mayor's offices, fire stations or church halls can become hubs for the dissemination of information (e.g. Deverell 2003, Scholtens et al. 2008). Such locations generally have a radio available, notices can be displayed and contact persons are available for the large numbers of people who congregate at the centres.

It is, however, clear that such fragmented (one-way) communication cannot meet the requirements as stated in the literature and in guidelines for »continuously coordinated« crisis communication (BBK 2008a, p. 147). If electricity-based communication fails as extensively as described above, it becomes extremely difficult to convey credibility and create trust on a local, regional or national level −i.e. to meet key basic conditions for crisis communications – without the assistance of functioning communications channels, which are taken for granted. However, the question of how preparations can be made for »temporary assistance for such a case« (BBK 2008a, p. 147) and of how alternative currentless communication that meets the needs of the respective target groups can be achieved is seldom addressed. There is a need here for conceptual and practical reflection on how currentless crisis communication could be structured.

In recent years there has been a growing awareness about the issue of alerting the public and ensuring a continued flow of information. Since the processes of alerting the public and lowering the alarm level require adequate infrastructures (Schutzkommission 2006, p. 48), technical options have been examined and also implemented in some cases in order to at least partially close existing »gaps in terms of the alert process« (Schutzkommission 2006, p. 50 ff.) and also to improve ways of informing and communicating with the public. However, while some technical solutions for alerting and educating the public may be elegant and sophisticated, they do not represent the optimum solution during a power cut. Such warning concepts are often based on mobile phone capabilities (e.g. sending mass SMS text messages using cell broadcast technology). Moreover, it has been proposed that cars, radio clocks or smoke alarms should be fitted with radio receivers to enable them to be used for alerting the public. Against the backdrop of such examples, when developing innovative solutions in particular

132 Like deNIS II plus, SatWaS relies on a supply of electricity.

it is advisable to also consider the special circumstances of a power blackout including consequences such as the widespread failure of communications infrastructures and the limited range of battery charges. In particular, it is important to avoid a situation where the people with relevant responsibility are »well informed« but the public affected by the disaster is largely »ignorant« of the situation (Schutzkommission 2006, p. 50 f.).

SUPPLY OF FUEL, ENSURING A STABLE EMERGENCY POWER SUPPLY 11.

The availability of fuel as a resource is vitally important for disaster management. The supply of fuel is indispensable for, for example:

- Emergency vehicles of the aid organisations and support forces;
- Diesel-operated rail vehicles to evacuate stranded trains and for transport purposes and also local public transport buses to maintain a minimum level of transport services;
- Emergency power generators that maintain the functionality of sensitive infrastructure components (e.g. emergency control centres, fire stations, mobile radio stations) as hubs for disaster management information, communications and coordination (e.g. Hoffman 2009, p. 24 ff.).

Despite the unfavourable underlying conditions (including in particular the loss of petrol stations), the existing management capacities in the form of fuel stocks offer the necessary prerequisites for ensuring the mobility that is required for those involved in disaster management. In addition, refineries have their own power generation capacities that can cover up to 90 % of electricity requirements; in many cases, their own power network can be operated as an isolated network (Hiete et al. 2020, F 20). Consequently, at least some refineries are likely to be in a position to continue with (reduced) operations.

The petroleum stocks prescribed by law mean significant reserves of fuel are available that could cover requirements even during a prolonged power blackout. Since petrol and diesel are mainly stored in above-ground tank facilities, the tankers or tank wagons can be filled using the principle of gravity (Prognos 2009, p. 84) if electricity is not available for the pumps. The fact that locations are well distributed across the regions ensures comprehensive availability (website of EBV a, b, d; ÖGEW/ DKGM 2007). The Traffic Services Act (VerkLG) allows for the option of making transport capacities of private companies available.

Despite this potential there are question marks over the extent to which these capacities and resources can be mobilised and used in a way that is tailored to requirements in the event of a power blackout.

A key obstacle could be the fact that issuing the required statutory instrument pursuant to Section 30 of the Petroleum Stockholding Act (ErdölBevG) could take some time. In such case, provision is made for stocks to be made available to the petroleum companies by the Petroleum Stockpiling Association (EBV)[133] (website of EBV c). Measures can also make provision for targeted release of fuel to certain purchasers. In such cases the released stocks must be transported by inland water vessels, rail tankers[134] or tanker lorries. However, the disruptions to communications and transport infrastructures may mean the transport vehicles can't be mobilised quickly and extensively enough to prevent fuel bottlenecks. It is also unclear whether, for example, the petroleum companies would be prepared for a situation involving the release of petroleum stocks (Hiete et al. 2020, F 21). It is also possible that stocks of companies or private individuals may have to be seized at local level in order to cover the requirements of vehicles operated by the authorities and the emergency services and also of relevant emergency power generators until such time as replenishment deliveries can be organised.

In addition, coordinating the distribution of fuel deliveries in line with requirements at local level is extremely complex, even if it does prove possible to mobilise sufficient tankers of petroleum companies and logistics service providers under the Traffic Services Act (VerkLG). Since a large area is involved, problems are likely to be encountered in agreeing responsibilities; logistics challenges (e.g. designating, establishing and operating central transhipment and distribution centres) can also be expected (EBP 2010, p. 104). Problems are compounded by the shortage of communications capabilities for authorities and task forces, resulting in many places receiving inadequate supplies, excess supplies or no supplies at all.

Overall, it is clear that although extensive measures are in place to guarantee transport services to supply fuel in the event of a crisis, the specific conditions of a power blackout mean that prompt, well-coordinated mobilisation of fuel reserves is a critical factor in determining further development of the situation and also in managing the associated consequences.

One means of increasing the sector's resilience would be to improve the resources available directly at local level (e.g. by ensuring selected petrol stations are equipped with emergency power generators and are supplied with fuel on a continuous basis). Assuming such fuel was made available to the public safety authorities and organisations and to the aid organisations on a priority basis, the time pressures for delivering fuel reserves would be reduced and the local mobili-

133 The EBV's computer network does not have an emergency power supply. If a power blackout were to last longer than 8 hours the EBV would relocate to a secure data centre (Hiete et al. 2010, F 21).

134 Rail tankers could not be used without problems in the event of a power blackout.

ty and ability of the emergency forces and also where applicable of the public to take action would be guaranteed for a certain time.

In order to ensure continuous operation of emergency generators, it would at the same time be necessary to replenish fuel stocks in time at selected relevant locations. To enable the complicated logistics process to run smoothly on a continuous basis, it is necessary to ensure IT networking for petroleum storage facilities, petrol stations and infrastructure elements that need to be supplied with emergency power generators and fuel. However, such a network does not yet exist.[135]

ISOLATED NETWORKS AS A MEANS OF INCREASING THE RESILIENCE OF THE POWER SUPPLY FOLLOWING A POWER BLACKOUT 12.

Individual sector analyses have revealed that many infrastructure elements are equipped with »uninterruptible power supply systems« (UPS) while certain facilities are equipped with emergency power generators. However, these generally have limited battery capacities or fuel reserves and therefore a low level of resilience. Once the direct contingency measures for a power blackout are exhausted, competition develops for mobile power generators in particular and also for the necessary fuel supplies. A large number of sensitive infrastructures in all sectors (e.g. milking systems, operating theatres in hospitals and mobile phone masts) compete for a very limited number of mobile generators and fuel. Although generators that have run out of fuel can be topped up or replaced with new generators, this only serves to gain an additional few hours. Ultimately, stationary and mobile emergency power generators need to be replenished with fuel after a few hours or days. Given the general restrictions in terms of logistics and coordination and also the number of customers and the competition among them, it is unlikely that it would be possible to provide adequate supplies for everyone.

Consequently, it is worth considering more sustainable options for increasing the resilience of key infrastructure elements and for managing a prolonged and widespread power blackout. This could, for example, be achieved through an emergency power supply concept based on decentralised power generators with isolated network capability[136] since only a few facilities permit an autonomous

135 Corresponding technical options are currently being examined by the Federal Ministry for Education and Research in a project entitled »The Supply of Energy and Fuel for Petrol Stations and Emergency Power Generators in the Event of a Power Blackout« (TankNotStrom) under the »Research for Civil Security« programme.

136 The »Smart Emergency supply System (SES2)« research project funded by the Federal Ministry for Education and Research is investigating how a minimum level of supply could be ensured during a prolonged power blackout by using renewable and decentralised power sources (www.bmbf.de/pubRD/Projektin formationen_SES2.pdf).

self-sufficient power supply (e.g. waste incineration plants or sewage treatment plants that have a »natural« fuel supply). The basic idea consists in equipping/networking selected critical infrastructure elements such as hospitals, (operations) control centres, facilities of public safety authorities and organisations or food warehouses with cogeneration and/or renewable energy plants, thus ensuring they are not affected by a power blackout.

The technical and economic feasibility of this concept could be tested in regionally restricted model projects. In particular, facilities with existing emergency power generators or co-generation plants that are relatively close to critical infrastructure elements could be used as starting points for establishing a self-sufficient power supply through an isolated network. Renewable energies would initially play a complementary role. Infrastructure facilities and public buildings would be networked with each other or in public-private partnerships with industrial plants, cogeneration power plants or in some cases with residential areas. This would enable authorities and emergency forces such as the police, fire services and emergency medical services to continue operating with virtually no restrictions during a prolonged and widespread power blackout. Since official communication paths still work, this enables a rapid assessment of the situation and a coordinated approach to managing the situation. Moreover, town halls, schools, swimming pools and church halls can be made available to the public for accommodation, supply and personal hygiene purposes. Hospitals can maintain and continue all key functions. The fragmented structure of the networks means it is not possible for all sectors to be supplied on a long-term basis. Also, a shortage of fuel forces many isolated networks to disconnect consumers after a short time to enable authorities, hospitals and contact centres to continue operating services for the public. Consequently, most establishments, companies and households connected to the isolated network remain without power. However, the fact that official communication paths are working makes it possible to organise local coordination of aid deliveries, thus safeguarding public order and safety.

Such a model project would also aim to ascertain the potential for technical innovation, market mechanisms and public subsidy programmes to activate learning curves and economies of scale.

An even more foresighted development strategy could involve incorporating isolated network solutions based on renewable energies into existing solutions, taking into account the specific characteristics of the respective locations and the facilities to be supplied, along with the findings of the model project. This would mean that the isolated network would take over supplying the most important critical infrastructure systems and functions in a disaster situation; in all other cases grid infeed operation would be selected. When planning and designing such a solution, however, it would be necessary to remember that a series of additional technical devices would have to be installed in order to synchronise power supply and demand. Where the power supply fluctuates, power storage devices must be included and management systems provided; certain cogeneration plants require an emergency cooler for operation outside the heating period. Technically speaking, such an approach does not involve insurmountable problems; however, it is important not to disregard the additional costs involved. Against this backdrop it is necessary to examine whether it would be possible to reduce the current economic restrictions by setting a political framework and introducing relevant incentives.

Looking to the future, a more intensive development strategy could enable cost reductions and increases in efficiency while also helping create a leading market for electrical engineering and battery technology in particular. Linking in with programmes to promote combined heat and power, renewable energies and the modernisation of the electricity grid infrastructure could generate synergistic effects (e.g. as regards storing fluctuating energy input).

PROVIDING INFORMATION TO AND HEIGHTENING AWARENESS AMONG THE POPULATION 13.

The discussion on the behaviour of the public during a power blackout raised additional questions on its role within disaster management. These questions concern, for example, the level of information available to the public, their preparedness and ability to help themselves and also the opportunities and limits regarding informing citizens and encouraging their ability to help themselves.

A significant deficit exists regarding the public's awareness and perception. The public does not consider the power supply as a critical infrastructure to be an important issue; the possibility of power blackouts and the consequences of an interruption to the power supply are ignored. The public feels assured that (major) power blackouts only occur in countries where the power supply is not very reliable. People who experience power blackouts are generally quick to forget them (Chapter III.3, p. 2; Stiftung Risikodialog 2007, p. 14). Media reporting primarily focuses on major power blackouts, which are a rare occurrence in Germany (Lorenz 2010, p. 18 ff.).

Disasters such as power blackouts are usually associated with extreme weather events and terrorism. Since natural events are perceived as unavoidable and terrorism is viewed with a certain fatalism, individuals believe they cannot take precautions against what are assumed to be exclusive causes (Lorenz 2010, p. 22). Consequently, the public is not prepared for a power blackout to any noticeable degree (e.g. Gardemann/Menski 2008) and people are therefore unable to cope adequately with the consequences.

In view of society's growing dependence on critical infrastructures, Lorenz (2010, p. 28) notes that this process »has not been given or has at least not been given adequate attention in terms of risk communication«. The resulting general low level of awareness surrounding the risk of and dangers of a power blackout limit the options available to the authorities for

- informing the public of dangers and risks and for heightening awareness
- encouraging the public to become prepared and ensure provisions are kept in stock,
- providing information by means of alerts in the event of a disaster and for
- mobilising individuals' ability to help themselves and others.

In principle, it can be said that communicating risks and possible dangers should create trust and that providing information and advice should maintain the public's interest and thus make it possible to address citizens in an appropriate way during a crisis situation (Geenen 2009, p. 91; Lorenz 2010, p. 26). It is unclear how risk communication or an awareness campaign concerning the risk of power blackout could be structured because little scientific literature is available on the public's attitude and opinions on the subject. Moreover, little is known on how information campaigns are perceived or on the effects of such campaigns. In this context, the first task consists in elaborating a scientific strategy for entering into risk communication with the public before a power blackout. One possibility could involve a citizens' or consensus conference on critical infrastructures. Another option is to consider involving citizens' groups in emergency planning. Participative processes such as these would help move away from the traditional approach of viewing citizens as passive disaster victims and would instead help integrate them more fully as competent, active players.

It is important to remember that the general disinterest in the subject shown by citizens should not be simply dismissed as an unwillingness to learn or as unreasonableness. The fact that the public behaves in such a way reflects a specific rationale – towards a risk whose consequences are indeed considerable but whose likelihood of occurring is low. A pedantic approach would therefore not be conducive.

CONCLUSION 14.

The consequence analyses have demonstrated that even after a few days, it is no longer possible to guarantee area-wide supplies of vital/necessary goods and services to meet the population's requirements within the region affected by the blackout. Public safety and security is jeopardised; the state can no longer meet its duty of protection, as anchored in the Basic Law, to protect the life and limb of its citizens. The state therefore also loses one of its most important resources – the trust of its citizens.

Although the probability of a prolonged power blackout affecting several federal states may be low, if such a case were to materialise the resulting consequences would be tantamount to a national disaster. Even if all internal and external forces and resources were mobilised, this would not be »controllable« and could at most only be mitigated. Historically, the German system of assistance may indeed have been well prepared for disasters, with »nothing« that »was impossible to overcome« (Unger 2008, p. 100). It is doubtful whether this also applies to a »combined disaster« of a power blackout.

Further efforts are therefore necessary at all levels in order to increase the resilience of critical infrastructure sectors in both the short and medium-term and also to further optimise the capacities of the national system for disaster control in a carefully targeted manner. However, it will not always be possible to implement corresponding measures without extra cost. It must be emphasised that the aim should be to achieve at least relative, rather than absolute, safety/security. It will at all times be necessary to consider various factors and set priorities during the development and implementation process: How safe is safe enough? What costs and what obligations are reasonable and for which players? What residual risk must be accepted?

The individuals with responsibility in politics and society should continue to accord high priority to the issue of a power blackout as a prime example of »cascading damaging effects«, not least in order to also raise awareness of the subject within industry and among the public. The present TAB report aims to contribute towards this.

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ANNEX VI.

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LIST OF ABBREVIATIONS 3.

AG KRITIS	Arbeitsgruppe Kritische Infrastrukturen – *Inter-ministerial Working Group on Critical Infrastructures*
AMG	Arzneimittelgesetz – *Pharmaceuticals Act*
ApoBetrO	Apothekenbetriebsordnung – *Ordinance on the Operation of Pharmacies*
ApoG	Apothekengesetz – *Pharmacies Act*
BBK	Bundesamt für Bevölkerungsschutz und Katastrophenhilfe – *Federal Office of Civil Protection and Disaster Assistance*
BCM	Business Continuity Management
BKA	Bundeskriminalamt – *Federal Criminal Police Office*
BMI	Bundesministerium des Innern – *Federal Ministry of the Interior*

BOS	Behörden und Organisationen mit Sicherheitsaufgaben – *Public safety authorities and organisations*
BPOL	Bundespolizei – *German Federal Police*
BSI	Bundesamt für die Sicherheit in der Informationstechnik – *Federal Office for Information Security*
BVN	Bundesverwaltungsnetz – *Federal Administration Network*
DB	Deutsche Bahn
deNIS	deutsche Notfallvorsorge-Informationssystem – *German Emergency Planning Information System*
DFN	Deutsches Forschungsnetz – *German Research Network*
DFS	Deutsche Flugsicherung
DVGW	Deutsche Vereinigung des Gas- und Wasserfaches – *German Technical and Scientific Association for Gas and Water*
DWA	Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall – *German Association of Water, Wastewater and Waste*
EBV	Erdölbevorratungsverband – *Petroleum Stockholding Association*
ESG	Ernährungssicherstellungsgesetz – *Emergency Food Control Act*
EU	European Union
EVG	Ernährungsvorsorgegesetz – *Emergency Food Supply Act*
GG	Grundgesetz – *Basic Law*
GMLZ	Gemeinsames Melde- und Lagezentrum – *German Joint Information and Situation Centre*
GSM-R	Global System for Mobile Communications-Rail
ISDN	Integrated Services Digital Network
IT	Information technology
IVBB	Informationsverbund Berlin-Bonn – *Berlin-Bonn Information Network*
IVBV	Informationsverbund der Bundesverwaltung – *Information Network of the Federal Administration*
KRITIS	Kritische Infrastruktur(en) – *Critical infrastructure(s)*
LÜKEX	Länder Übergreifende Krisenmanagement-Übung/EXercise – *National Crisis Management Exercise*
MIC	Monitoring and Information Centre
MSC	Mobile services Switching Centre
NATO	North Atlantic Treaty Organization
NdB	Netze des Bundes – *Federal Networks*
NPSI	Nationaler Plan zum Schutz der Informationsinfrastrukturen – *National Plan for the Protection of Information Infrastructures*
PTSG	Post- und Telekommunikationssicherstellungsgesetz – *Law Concerning the Transformation of the Deutsche Bundespost Enterprises into the Legal Structure of Stock Corporation*

SatWaS	Satellitengestütztes Warnsystem – *Satellite-based warning system*
StVollzG	Strafvollzugsgesetz – *Prisons Act*
THW	Bundesanstalt Technisches Hilfswerk – *Federal Agency for Technical Relief*
TierSchNutzVO	Tierschutz-Nutztierhaltungsverordnung – *Animal Welfare Livestock Husbandry Ordinance*
TC	Telecommunications
TKG	Telekommunikationsgesetz – *Telecommunications Act*
TKSiV	Telekommunikations-Sicherstellungs-Verordnung – *Ordinance ensuring the Provision of Telecommunications Services*
TrinkwV	Trinkwasserverordnung – *Drinking Water Ordinance*
UPS	Uninterruptible power supply
VerkLG	Verkehrsleistungsgesetz – *Traffic Services Act*
VoIP	Voice over IP
WasSiG	Wassersicherstellungsgesetz – *Law to Safeguard the Water Supply*
WHO	World Health Organisation
WpHG	Wertpapierhandelsgesetz – *Securities Trading Act*
ZMZ	Zivil-Militärische Zusammenarbeit – *Civil-military cooperation*
ZSKG	Zivilschutz- und Katastrophenhilfegesetz – *Civil Protection and Disaster Management Law*

TAB

BÜRO FÜR TECHNIKFOLGEN-ABSCHÄTZUNG
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