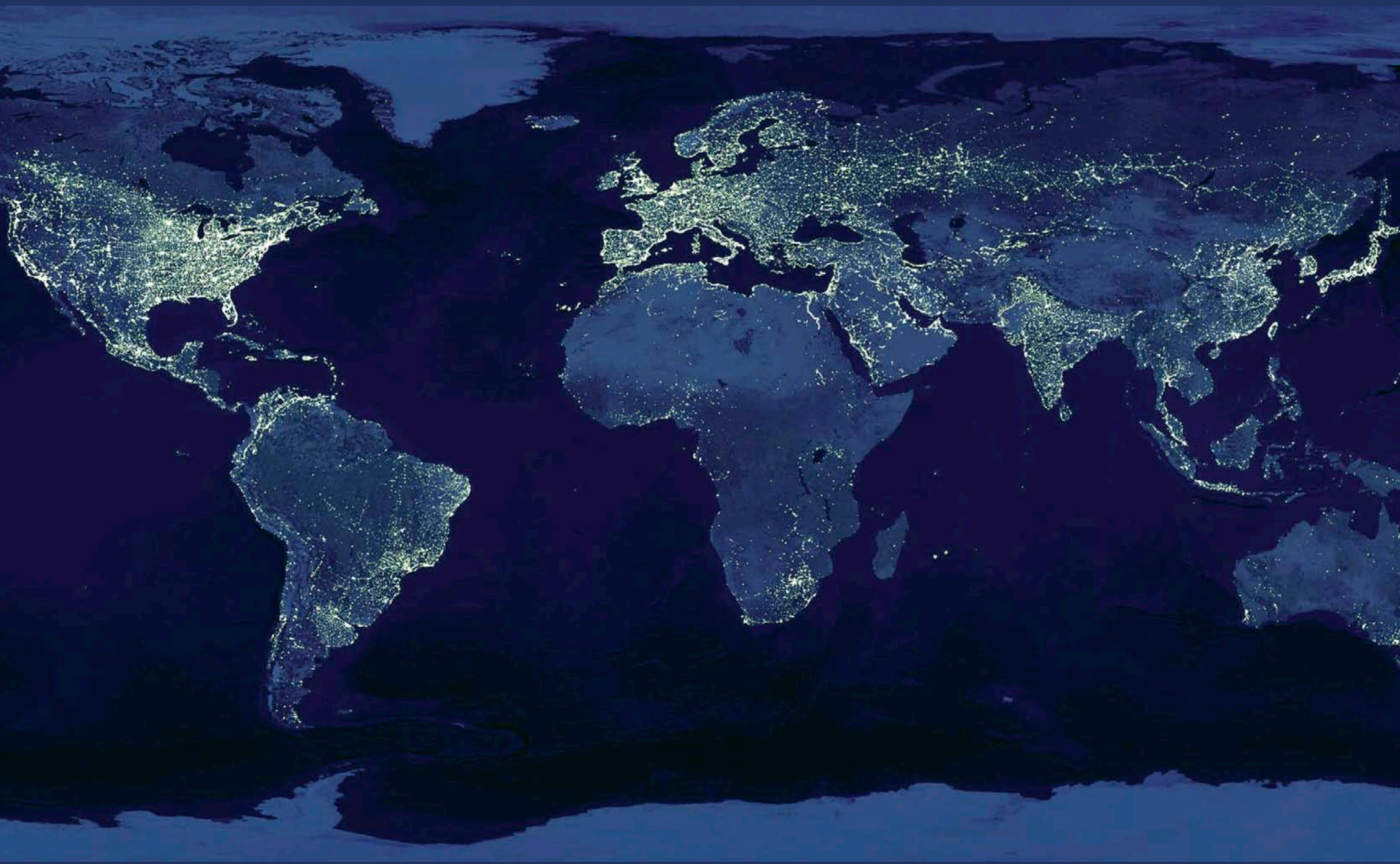

Power Blackout Risks

Risk Management Options

Emerging Risk Initiative – Position Paper

November 2011

CRO FORUM

Content

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1. Summary

Blackouts during the last ten years in Europe and Northern America have demonstrated an increasing likelihood of supra-regional blackouts with accompanying large economic losses. The earthquake, tsunami damage and power shortages that idled thousands of Japan's factories in 2011 highlighted its role as a key – and sometimes the only – source of auto parts, graphics chips and other high-end components. Many manufacturers are currently using up the inventories that they had in stock before the earthquake. A similar situation could occur as a result of a larger power outage and this risk may further increase in the future. One reason are insufficient incentives to invest in reliable power supply infrastructures. But new and smarter grids including storage capacities (e.g. pumped-storage hydropower plants) are required to handle the future growth of volatile renewable energies, which are located far away from the centres of demand. Furthermore the vulnerability of the power supply industry, the industrial and commercial companies and the public and private sector is high due to the interconnectedness and dependency of all areas on Information and Communication Technology (ICT), navigational systems and other electronic devices.

Whereas short term power blackouts are experienced frequently on a local or regional level around the world (e.g. caused by natural catastrophe events like earthquakes, storms, floods or heat waves), societies are not familiar with large scale, long-lasting, disruptive power blackouts. Traditional scenarios only assume blackouts for a few days and losses seem to be moderate, but if we are considering longer lasting blackouts, which are most likely from space weather or coordinated cyber or terrorist attacks, the impacts on society and economy might be significant.

So far insurance companies were not affected significantly beyond taking care of their own business continuity management in order to mitigate losses following a blackout. Risk transfer via insurance has usually required physical damage to either the insured's assets or the assets of specific service providers to trigger a business interruption claim. But only 20% to 25% of business interruptions, such as supply chain disruptions are related to a physical loss[1]. Therefore insured persons and organisations should be aware that they may face huge uninsured losses. This might trigger an increasing demand for new risk transfer solutions related to power blackout risks in the future.

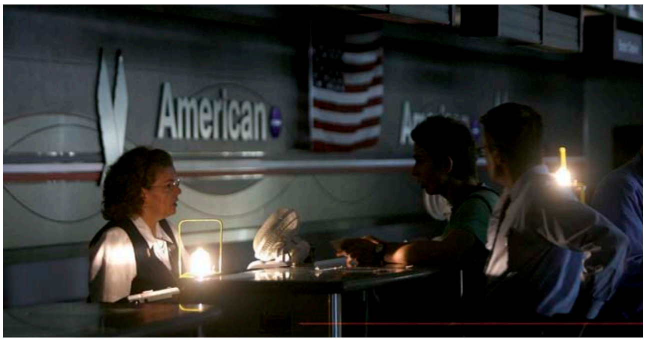
The insurance industry can offer well contained event covers which fulfil the principles of insurance: randomness, assessability, mutuality and economic viability whereas utilities and governments have to increase their efforts to make our power infrastructure resilient against such events.

[1] http://fpn.advisen.com/articles/article140935191888258975.html

2. Power blackouts challenge society and economy

Electricity is the backbone of each industrialised society and economy. Modern countries are not used to having even short power blackouts. The increased dependency on continuous power supply related to electronics, industrial production, and daily life makes todays' society much more vulnerable concerning power supply interruptions. A brownout (reduced voltage) of some minutes or a similar blackout (complete failure of electricity supply) may cause some inconvenience at home such as having the lights turn off. But a blackout of a few hours or even several days would have a significant impact on our daily life and the entire economy. Critical infrastructure such as communication and transport would be hampered, the heating and water supply would stop and production processes and trading would cease. Emergency services like fire, police or ambulance could not be called due the breakdown of the telecommunication systems. Hospitals would only be able to work as long as the emergency power supply is supplied with fuel. Financial trading, cash machines and supermarkets would in turn have to close down, which would ultimately cause a catastrophic scenario. If the blackout were to spread across the border lines, which is more likely today due to the interconnection of power grids between different countries, the impacts would escalate as a function of the duration of the interruption.

The following position paper highlights the risks and future trends linked to power blackouts. It further explores risk management options including operational risk management measures, the importance of a high quality business continuity management plan and risk transfer options. Furthermore it emphasizes the insurance industry's options to expand coverage based on physical damage and to consider new non-physical damage insurance solutions. This might be insurance cover or alternative risk transfer solutions, which respond and cover emerging risks such as power outages, but also political risks, pandemics and/or supply chain disruptions.



picture alliance/dpa

3. Blackout risks on the increase

3.1. How power market trends influence blackout risks

The worldwide power supply industry experienced two major changes in the last ten to twenty years:

- Liberalisation and privatisation
- Expansion of renewable energy production capacities

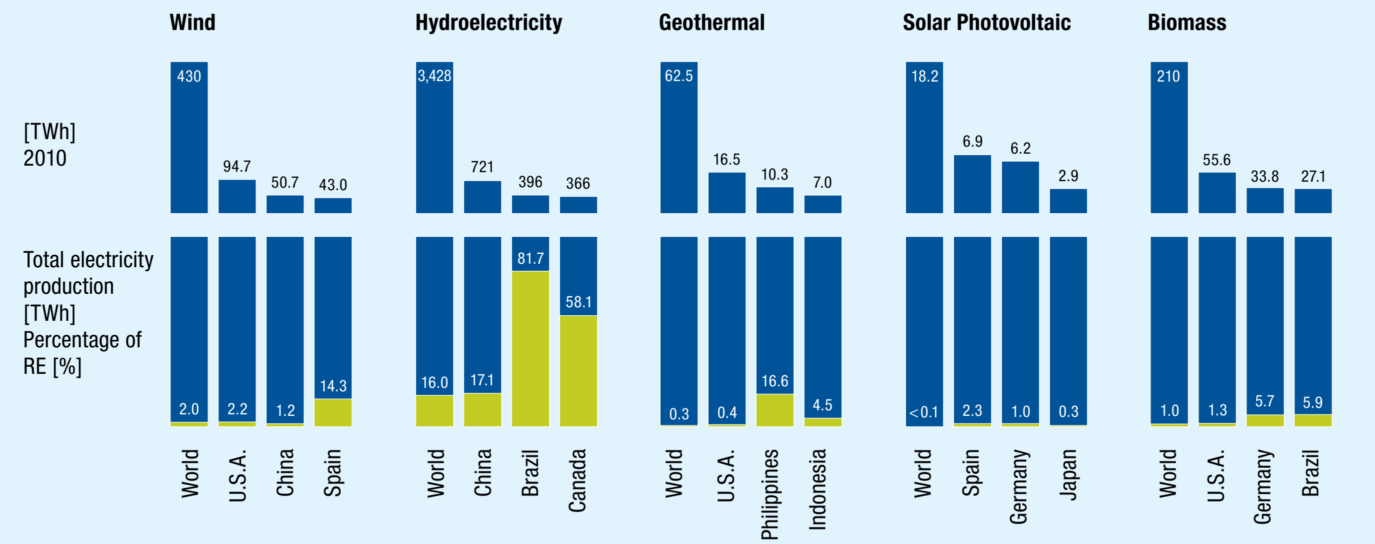
3.1.1. LIBERALISATION AND PRIVATISATION[2]

Nowadays, most industrialised countries have 10 to 20 years experience with privatisation and liberalisation of electricity systems. The liberalisation of the market resulted in the separation of power generation and transmission and distribution (T&D) business. This process has created an additional interface which can adversely impact communication and coordination activities between operators on both sides. The past blackout events reveal (*see boxes in 3.2.1 and annex*) that underlying causes are also partly linked to the privatisation and liberalisation trends due to missing incentives to invest in reliable, and therefore well maintained, infrastructures. The discrepancy is further described in chapter 3.1.3.

3.1.2. RENEWABLE ENERGIES[3]

Efforts to mitigate climate change across the world are focusing on the expansion of renewable energy production e.g. onshore and offshore wind farms, solar and biomass power plants. Half of the estimated 194 gigawatts (GW) of newly added electric capacity worldwide in 2010 is represented by renewable energies which was an increase of 8% compared to 2009. According to the World Wind Energy Association (WWEA), about 175,000 megawatts (MW) of energy are now being produced by wind power stations around the world. Leading producers are the United States, China and Spain. The European Union intends to increase the renewable energy share of total energy production to 20% by 2020.

Figure 1[4]: The top three countries for Renewable Energy electricity production



[2] http://www.psiru.org/reports/2009-12-E-Indon.doc
[3] http://www.ren21.net/Portals/97/documents/GSR/GSR2011_Master18.pdf
[4] http://www.energies-renouvelables.org/observ-er/html/inventaire/pdf/12e-inventaire-Chap02.pdf

A downside of renewable energy particularly, wind and solar technologies, is the volatile supply of power. Not only may a scarcity of electricity result in a power blackout, but an oversupply can also lead to grid instabilities as they alter the frequency within the network. For example wind energy in East Germany during strong wind conditions can provide up to 12 GW, which is more than all German coal and gas fired power plants considered together. This is not critical as long as there is enough electricity demand, but may lead to grid instabilities in cases of insufficient demand as there is not enough electricity storage capacity available. To get rid of excess electricity, transmission system operators (TSOs) often have to pay an extra fee to the electricity market (EEX – European Energy Exchange, Leipzig). Otherwise wind park operators have to be convinced to stop the wind turbines immediately in order to prevent grid instabilities and blackouts. Conversely wind turbines must be stopped due to safety reasons if the wind speed exceeds 30 m/sec. This scenario may cause, within one hour, power gaps equal to the performance of two nuclear power plants. In such cases conventional reserve power plants are required to step in instantly.

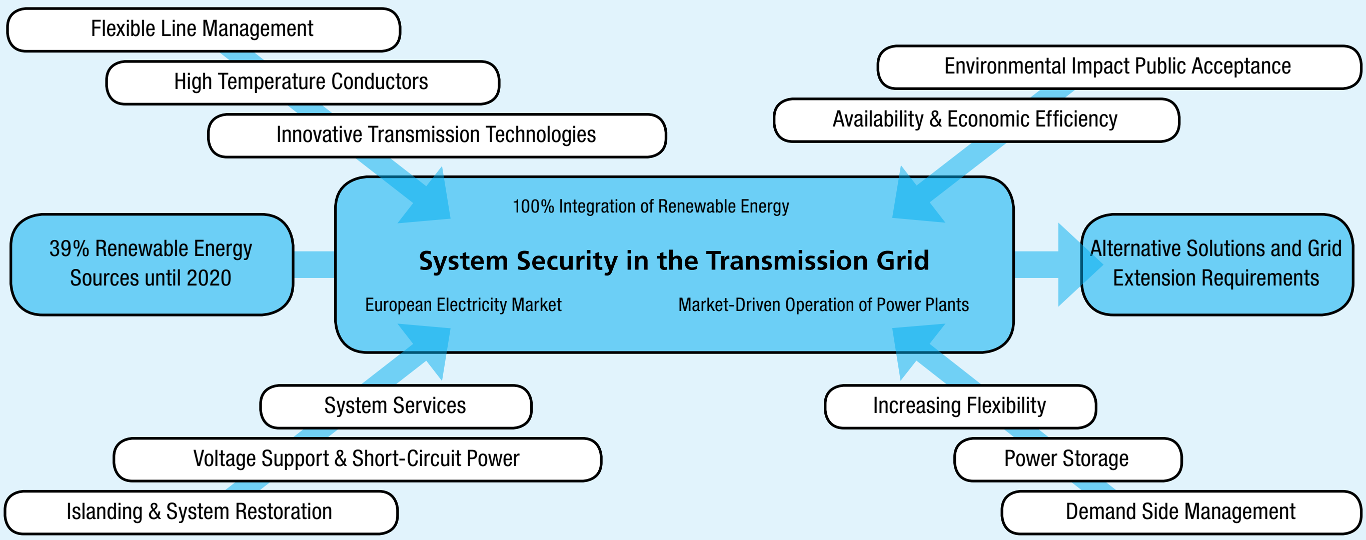
In addition, the location of e.g. windfarms (onshore and offshore) is often far away from the centres of demand. Electricity has to be transported from sparsely populated regions to large electricity consumers in metropolitan areas. Therefore, new energy infrastructure (new high voltage transmission lines, transformers and energy storage capacities such as pumped-storage hydropower plants or thermal storage facilities) are needed.

Grids need to become much "smarter" to handle these enormous technical challenges. Therefore a large-scale smart grid is needed that integrates and automatically and efficiently coordinates the activities of all players both on the electricity supply and the demand side.

3.1.3. HUGE INVESTMENTS IN POWER SUPPLY INFRASTRUCTURE REQUIRED[5]

The following figure from the grid study published by dena (German Energy Agency[6]) shows how many critical issues have to be taken into account to plan a future transmission grid that responds to both the increased proportion of renewable energy production and future requirements of a modern and sustainable power supply:

Figure 2: Challenges for a future transmission grid



Source: dena

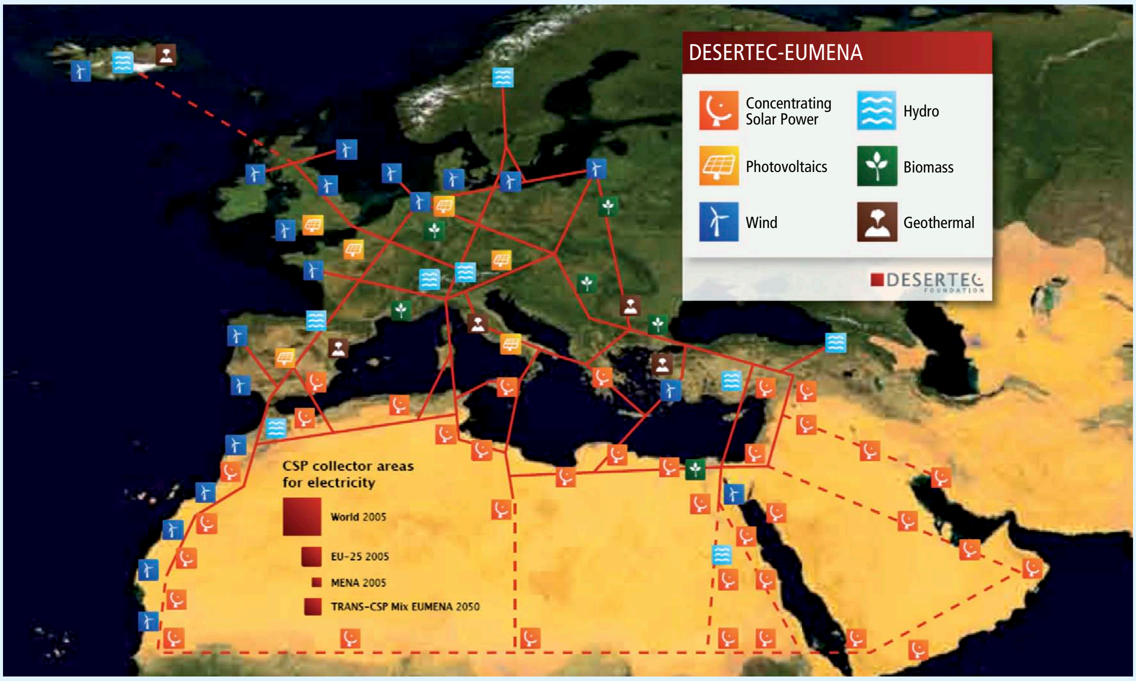
[5] EIA, Annual Energy Outlook 2011, http://www.eia.gov/neic/speeches/newell_12162010.pdf
[6] http://www.dena.de/fileadmin/user_upload/Download/Dokumente/Studien___Umfragen/Summary_dena_Grid_Study_II_2.pdf (November 2010)

The dena grid study concludes that for Germany alone an additional 3,600 kilometres of 380 kilovolt lines will be required by 2020. For comparison, since 2005 just 80 km of new power grids were erected.

For the European Union grids investments of EUR 23-28 bn are needed over the next five years. This could only be realised if investment and permitting processes are pushed and financing incentives for TSOs are supported by the EU members, regulator bodies and industry.

Worldwide an investment of USD 13.6 trillion will be required by 2030 in order to meet increasing demand (International Energy Agency, IEA). IEA concludes that 50% of this amount needs to be invested in transmission and distribution and another 50% in generation of electricity.

One of the most prominent projects that address these requirements is the Desertec project. The below chart highlights the necessity of long distance transmission capabilities in order to efficiently use and distribute renewable energies.



CSP: Concentrated Solar Power
Squares indicate the area required to meet the respective power demand

Source: Desertec Foundation

3.2. Historical power blackout events and future scenarios

3.2.1. HISTORICAL BLACKOUTS

The ten most severe blackouts concerning affected population and duration

New Zealand
20.02.1998

Technical failure, a chain reaction caused by a line failure
4 weeks 70,000

Brazil (70% of the territory)
11.03.1999

Natural event, a chain reaction was started when a lightning strike occurred at 22h at an electricity substation in Bauru, São Paulo State causing most of the 440 kV circuits at the substation to trip. Urban chaos led by huge traffic jams and public subway and suburban trains systems that were out.
5h 97,000,000

U.S.A. (North-East) + Canada (Central)
14.08.2003 (detailed description see Annex)

A combination of lack of maintenance, human error and equipment failures caused an outage that affected large portions of the Midwest and Northeast United States and Ontario, Canada. This area typically has a total electric load of 61,800 MW. The blackout began a few minutes after 4:00 pm Eastern Daylight Time and power was not restored for 4 consecutive days in some parts of the United States.
4 days 50,000,000
Economic losses: about USD 6 bn

Italy (all Italy, except Sardinia)
28.09.2003 (detailed description see Annex)

Technical failure, a domino effect that ultimately led to the separation of the Italian system from the rest of the European grid. 30,000 people were trapped on trains. Several hundred passengers were stranded on underground transit systems. Many commercial and domestic users suffered disruption in their power supplies for up to 48 hours. The subway had to be evacuated.
18h 56,000,000 Deaths: 4

Indonesia (Java Island)
18.08.2005

Technical failure, power failed along the electrical system that connects Java, Bali, and Madura, causing outages in Java and Bali. This led to a cascading failure that shut down two units of the Paiton plant in East Java and six units of the Suralaya plant in West Java.
7h 100,000,000

Spain
29.11.2004

Human error/technical failure, overloaded transmission line
5 blackouts within 10 days 2,000,000

South West Europe (parts of Germany, France, Italy, Belgium, Spain and Portugal)
04.11.2006 (detailed description see Annex)

Human error, the fault originated from Northern Germany, from the control area of E.ON Netz. On November 04, 2006, a high voltage line had to be switched off to let a ship pass underneath. Additionally during that time there was a strong wind which fed into the grid 10,000 MW from wind turbines to Western and Southern Europe grids. Insufficient communication about this switch-off led to instabilities of the frequency in the grid and to the overloading of lines, which ultimately resulted in the splitting of the Electricity Transmission network into three zones: West, East and South-East. The Western zone lacked power and the Eastern zone had too much power.
2h 15,000,000

Brazil (most states) + Paraguay
10.11.2009

Natural event, heavy rains and strong winds caused three transformers on a key high-voltage transmission line to short circuit, cutting the line and automatically causing all of the hydroelectric power plant's 20 turbines to shut-down due the abrupt fall of power demand (the world's second largest hydroelectric dam).
Thousands of people were trapped in elevators, subways and suburban trains. Road traffic was also chaotic as the power outage darkened traffic lights, and the police were put on high alert as an outbreak of crime was feared. Only large office buildings and hotels with generators were lit. The country's largest airports were also using generators and providing limited emergency service, they said. Brazil's phone network largely collapsed, but its mobile-phone network was still operating.
25min to 7h 87,000,000

Brazil (at least 8 states in northeastern: Alagoas, Bahia, Ceará, Paraíba, Pernambuco, Piaui, Rio Grande do Norte and Sergipe)
04.02.2011

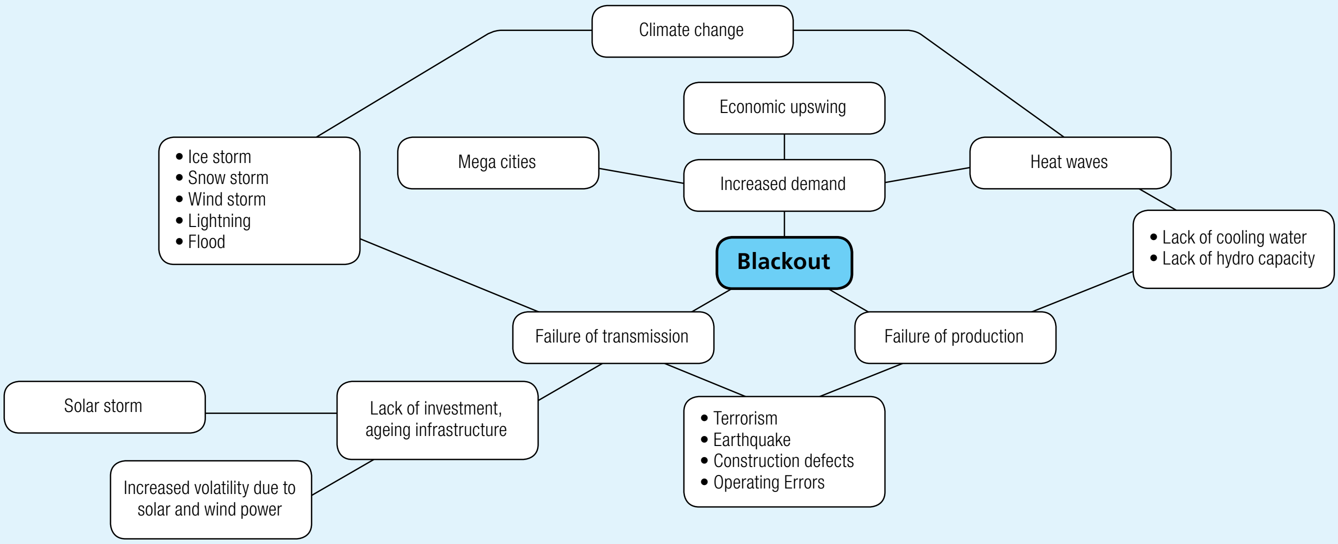
Technical failure, a failure in an electronic component that was part of protection system of the concerned substation.
16h 53,000,000

India
02.01.2001

Technical failure, failure of substation in Uttar Pradesh.
Some major hospitals were able to function using back-up generators but others were paralysed and some major surgeries had to be cancelled. The water supply also broke down after treatment plants and pumping stations stopped functioning. Millions of people were unable to draw water from underground wells because the pumps were not working. The northern rail system was in chaos as electric trains halted blocking the lines. More than 80 trains were stranded for about 15 hours across the region. Railway authorities used diesel engines to pull the electric trains to their destination but there was a shortage of diesel locomotives. Major cities including New Delhi rapidly clogged with traffic as the traffic signals went out. Land and mobile phone services were severely affected. Airline computers failed, stopping the reservation procedures. Although Delhi international airport was able to avoid major flight disruptions by using stand-by generators, most of the airport was in darkness.
12h 226,000,000
Economic losses: USD 110 m

3.2.2. WHAT ARE THE CAUSES OF BLACKOUTS?

Figure 3: Potential causes of power blackouts



Typically power blackouts are not caused by a single event but by a combination of several deficiencies. There is no outage known where a faultless grid collapsed completely due to a single cause. The following preconditions are the basis for a high power outage risk:

- High grid utilisation or high power demand
- High power plant utilisation
- Defects due to material ageing

If the following events occur in combination with the above mentioned conditions there is a very high likelihood for a power blackout to occur:

- Power plant shutdown for revision or due to supply failures (e.g. cooling water shortage during heat waves)
- Unforeseen simultaneous interruptions of several power plants
- Human failure during maintenance work or switching operations
- Simultaneous grid interruption e.g. short circuit caused by tree contact, excavation work, balloons drifting into power lines, cars hitting utility poles, provisional shutdown due to electrical overloading risk
- Sudden simultaneous high power demand, e.g. simultaneous usage of air conditions during hot summers
- Power line collapse or electrical equipment breakdown due to natural hazards (e.g. wind, earthquake, snow or ice load, flood, lightning, space weather, extreme temperatures)
- Insufficient communication between transmission/distribution system operators (TSO/DSO) and power suppliers
- Cyber attacks

Power supply as potential terrorism and military target

Power supply industry is classified as a critical infrastructure. These are organisational and physical structures and facilities of such vital importance to a nation's society and economy that their failure or degradation would result in dramatic consequences.
For this reason, power supply systems have always been military targets and can also be in focus for terrorist groups which want to undermine economic and social stability.

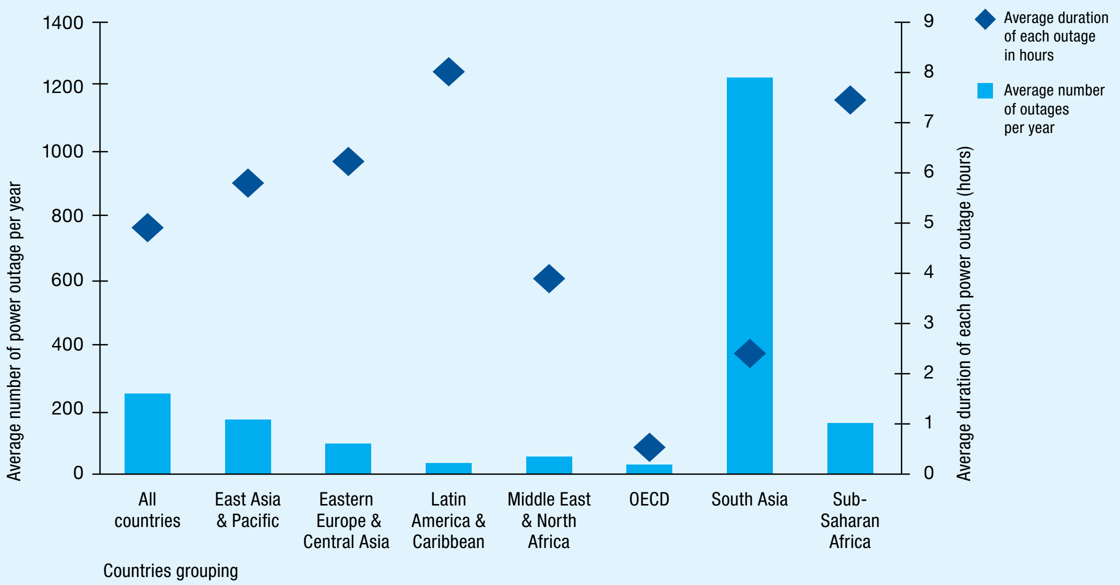
BOMBING:
Acts of war, terrorism and sabotage may focus on dams, power plants, substations and high voltage transmission lines.
During the Korean 1952 war U.S. military attacked several dams and power plants to wipe out roughly 90% of North Korean electricity generation.
In April 1995 anti-nuclear energy activists bombed the main 380 kV supply line for Vienna in Ebergassing (Austria). Two of the four bombs detonated too early because of the electric induction too early and killed the activists without causing damage to the line.
In January 2005 a high voltage line was damaged by terrorists in Georgia.
Several terrorist groups have threathened to destroy dams in the U.S., leading to high security efforts and the closure of many dams since 9/11.

CYBER ATTACKS:
During the last decade the likelihood of so-called cyber attacks increased. Such attacks try to shut down or destroy critical power supply components, e.g. large generators or transformers, via the Internet.
Vulnerability for cyber attacks has risen substantially due to the ongoing move from propriety software to IP-(internet protocol) based systems that use commercial software, which can be attacked by intruders.
The U.S. Aurora test in 2007 showed how a generator room at the Idaho National Laboratory was remotely accessed by a hacker and a USD 1 m diesel-electric generator was physically destroyed.
Another example, the **Stuxnet** virus which was developed to obtain control over the operation of Iran's nuclear power plants, demonstrates new possibilities in cyber attacks used not only by individual criminals or terrorists, but also by foreign states.

HEMP AND IEMI ATTACKS:
It is well known that nuclear bombs emit a strong electromagnetic pulse. If detonated at high altitudes (> 100 km) above the earth's surface such bombs are called a HEMP (high altitude electromagnetic pulse) weapon. Already in 1962 a military test 400 km above the Pacific proved the power of such an attack.
As an unintended side effect the power and telephone infrastructure of Hawaii was affected despite the small bomb (1.4 Mt) and the far distance (1500 km) from the point of detonation.
IEMI (Intentional Electro Magnetic Interference) attacks use special high power electromagnetic weapons without any of the side effects of a classic explosion and with limited impact area.
Both such weapons have the capacity to cause similar types of damage, such as severe solar storms (*see separate box*). HEMPs or IEMIs can lead to severe physical damage to all unprotected electronics and transformers by inducing several 100 to 1000s of volts. Typically microchips operate in the range of 1.5 to 5 volts and are therefore not capable of withstanding such voltages. The impact area can be in the range of several hundred meters to an entire continent.
In the U.S. the **Commission to Assess the Threat to the United States from Electromagnetic Pulse Attack** (http://www.empcommission.org) researches the effects and mitigation measures to such attacks.

3.2.3. AVERAGE BLACKOUT DURATION PER COUNTRY

Figure 4: Outages per year and duration, 2009[7]



Source: World Bank

Reliability of power supply varies significantly across regions (*Figure 4*). Even within OECD countries the quality of supply is not uniform and power outages quite severly impact economy. The United States, as an example, has an average of nine hours of disruptions each year for every consumer. Those interruptions are estimated to result in economical losses of least USD 150 bn each year. Compared to other industrialized countries the reliability of the U.S. grid is 5-10 times less than in major European countries. The average electricity consumer in U.S. has to cope with approx. 30 times more service interruptions each year than in Japan or Singapore. U.S. grid stability will decrease in the future if there are not enough investments in the infrastructure.

The October 2007 study, “2007 Long-Term Reliability Assessment,” of NERC (North American Electric Reliability Corporation) came to the following conclusions:[8]

- Long-term capacity margins on the nation’s transmission systems are inadequate to protect these systems from interruptions such as brownouts or blackouts. Absent immediate investments, this condition will worsen over the next decade;
- Projected increases in peak demand for electricity exceed projected additions of generation capacity;
- The areas of greatest concern are California, the Rocky Mountain states, New England, Texas, the Southwest, and the Midwest.
- In total, the U.S. will require about 120 GW of new generation just to maintain the minimum 15 percent capacity margin required for system reliability.

[7] World Bank study, http://siteresources.worldbank.org/EXTESC/Resources/Approach_paper_annexes_14_October_2009.pdf
[8] http://www.oe.energy.gov/DocumentsandMedia/Attachment_1_Nextgen_Energy_Council_Lights_Out_Study.pdf.pdf

4. Potential blackout scenario

A regional blackout lasting more than several days already could be considered as a “worst case” scenario. Most back-up and security systems will fail after a longer period without electric power, leading to an almost complete failure of most critical infrastructures.

As shown before such a scenario could be caused by a wide range of events.

For example, during the European heat wave of 2003, generation of electricity of power plants, incl. nuclear plants, had to be reduced due to the scarcity and high temperatures of the adjacent water bodies which are substantial for cooling purposes. Almost all rivers had record low water levels leading to reduced hydroelectric generation. Due to the massive lack of wind even wind generation capacity was down significantly. Prolonged heat waves may additionally result in a drop in biomass production due to reduced growth of plants.

If such preconditions coincide with a high electricity demand and increasing instability in the power grid, there is the potential for a supra regional collapse.

A comparable collapse can also be caused by a severe geomagnetic storm or an HEMP attack, due to the simultaneous damage to several key transformer locations and/or high voltage transmission lines. (OECD report 2011.[9])

4.1. Consequences

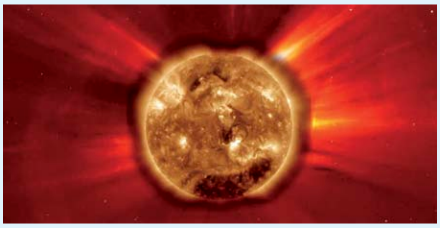
Most critical systems such as hospitals, first responder facilities, water and sewage systems and stock exchanges have backup power generation in place. However, these typically have only enough fuel for several hours to a maximum of a few days.

Immediately after a blackout, it is not possible to purchase any goods without cash as no electronic payment is possible. The 2003 blackout illustrated that after 3 to 6 hours without power most fuel stations and the refineries had to close down, leaving the public without fuel for cars or backup generators as the pumps did not operate. Aluminium melting furnaces will already sustain irreversible physical damage after 4-5 hours without electricity.

Governments have typically, however, implemented emergency fuel storages to keep most critical facilities alive for several weeks up to a month.

After one month with no electrical power, water, transportation, emergency services, critical manufacturing, and chemical sectors can face widespread outages within the affected region. The loss of water systems due to a power outage leads to many cascading effects. Hospitals, schools, nursing homes, restaurants, and office buildings all rely on water to operate. Water is used for drinking, sanitation, and heating and cooling systems in those facilities. Many manufacturing operations either use water as an ingredient in their processes or rely on wastewater systems to remove and process their manufacturing waste. Fire fighters depend on water to carry out their emergency response, and access to safe water is necessary for providing mass care services and preventing the spread of disease. Without electricity most heating systems do not operate. During winter typical homes can cool to below freezing level within few days. It must be expected that people will try to heat their homes using open fires, leading to many homes burning while there is no water for emergency response teams.

[9] http://www.oecd.org/dataoecd/57/25/46891645.pdf



Space weather

The term space weather summarizes different astrophysical effects the earth is exposed to. Constantly emitted clouds of electrically charged particles (plasma) from the sun into space are called solar wind. Large eruptions of plasma from the sun's corona are known as coronal mass ejections (CME) and create solar storms. The sun follows an 11 year cycle of changing solar activity with the next maximum expected in 2013. During a solar maximum 1 CME reaches the earth's orbit every 5 days on average, while during a solar minimum only 1 CME reaches our planet every 45 days.

A solar storm that reaches earth, generates intensive showers of particles and gigantic currents in the ionosphere (producing bright auroras) and induces major alterations in the geomagnetic field resulting in a geomagnetic storm. Large scale electric conductors in the changing magnetic field, whether cables or pipes, run currents called geomagnetically induced currents (GIC). Depending on the underneath geology long power lines connect (or short circuit) regions of different geoelectric potential. This can trigger GIC (up to 200 Ampere or more over time spans of more than 10 seconds) to enter the power grid through transformer grounding cables. The electromagnetic induction is higher the longer the transmission line and more severe for east-west directed transmission lines.

While power grids normally work with alternating currents they are not designed to handle direct currents (like GIC) induced by a geomagnetic storm. Those currents affect the electricity infrastructure, in particular high-voltage regulating transformers and substations, but also telecommunication networks and even pipe lines are exposed. GIC could hold the power to not only cause tripping of transformers but also damage or even destroy transformers, resulting in a different quality of power outage, i.e. not only large-scale but also long-lasting.

The first historical event where GIC appear to be linked to a large loss was a telegraph breakdown on September 2, 1859 – the so-called Carrington event. The day before, scientists detected a spectacular solar flare that had triggered a series of CMEs, followed by the largest aurora ever reported. At the same time, the extreme geomagnetic storm overloaded telegraph lines worldwide, causing short circuits and fires in telegraph stations and ultimately a breakdown in service.

More recently on March 13, 1989, during a large magnetic storm accompanied by vivid auroras visible as far south as Hawaii and Cuba, GICs hit power lines from the Hydro-Québec power network. This led to a blackout affecting 6 million people and losses of more than CAD 10 million. The increasing dependence of society on electricity and electronics, and of course satellites (e.g. GPS timing signals), leads to a growing exposure to strong space weather events, amplified by over-aged or sometimes degraded high-voltage equipment. ►

Scenario of large-scale and long-lasting power outage

Worst case solar storm scenario:

- A severe geomagnetic storm (similar to the Carrington event of 1859) distorts the Earth's magnetic field creating colourful aurora effects on the night sky. Multiple transformers fail (either tripping or damage) with cascading effects leading to a widespread power outage in the Northern Hemisphere (mainly affected areas include Canada, U.S.A., Scandinavia and Russia). Water, food, and fuel supply is disrupted, financial transactions stop, communication channels are interrupted and transportation of goods get challenging. As transformers have typical replacement periods of several months up to a year the power blackout might last longer than a few months.

U.S. Storyline for worst case U.S. impacts*

- Affected U.S. regions with > 130 m people affected
- Assumptions: strength as May 1921 event (10x strength of 1989 events, but less strong than 1859 Carrington event)
- 300 transformers affected; delivery time per transformer about 12 months
- Economic costs > USD 1 trillion
- Further impacts include satellite damage, GPS signal disturbance, telecommunications break-down and industry dependent on electricity.

This worst case scenario is mainly based on assumptions of widespread catastrophic transformer damages, long term blackouts, lengthy restoration times, and chronic shortages which will take 4 to 10 years for a full recovery.

Such a scenario – although unlikely – can have devastating economic impacts and will also impact many industries. The insurance industry covers which could potentially be affected include:

– **Property:** commercial and industrial business as well as personal lines

– **Liability:** general liability, Directors and Officers liability

– **Credit:** risk of businesses running into insolvency

– **Marine:** no loading/unloading of cargo – supply chain disruptions

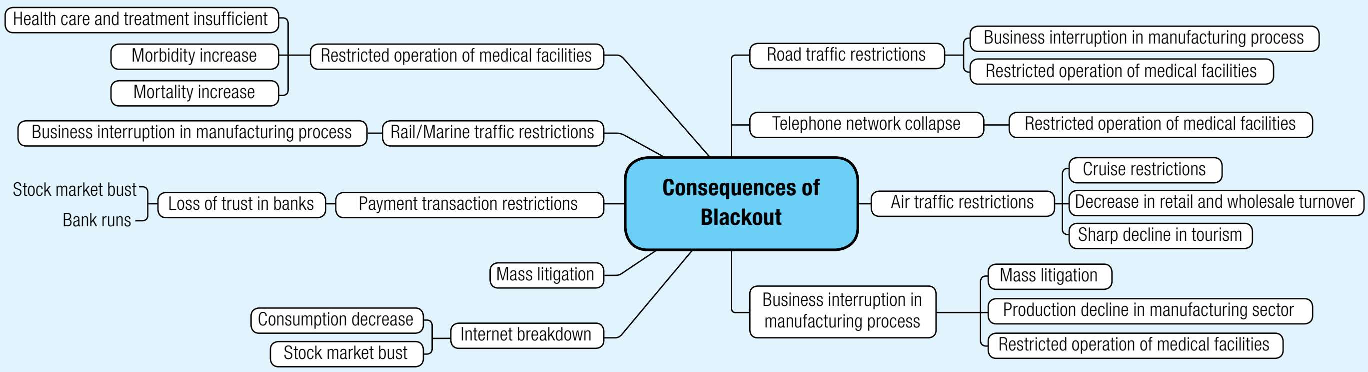
– **Space:** dramatically enhanced radiation risk for astronauts, damage to solar panels and electronics of satellites, malfunction of steering on-board computers

– **Aviation:** loss of communication, polar routes have to be rerouted.

What lies ahead? As far as solar activity is concerned, for centuries it has been shown that a very constant cycle exists that peaks every 11 years. In 2008, we hit a low point. The next peak is expected around 2013. Technological mitigation options to protect against GIC impacts include engineering solutions (increasing the electrical robustness against GIC, hardening of equipment) and improved operating procedures (based on reliable forecasts). The simplest but probably also most expensive solution would be the provision of back up transformers. Costs per transformer are in the range of USD 10 million. But there are also other possible exposures leading to large scale power blackout such as terrorist attacks (e.g. using Electro-Magnetic Pulse bombs – *see separate box*) or cyber attacks.

* after John Kappenman (Metatech Corp.)

Figure 5: Consequences of blackouts



Direct costs of blackouts are lost production, idle labour and facilities, damage to electronic data, spoiled food and damaged products, damage to equipment or customer refunds. Indirect costs are looting, accidental injuries, legal costs, loss of water supply. In general indirect costs exceed direct ones by up to 5 times.

4.2. Cost analysis of historic blackout scenarios[10]

Analyses of historic blackout events in U.S. show average electric customer interruption costs for medium and large industrial clients of between USD 15,709 for a 30 minute blackout and USD 93,890 for an 8 hour interruption. There is a wide range of costs depending on the industrial sector (medium & large clients). For an 8 hour event agricultural firms have the lowest costs with USD 41,250 per event, whereas construction firms have costs of USD 214,644 – a factor of 5.[11]

It is difficult to get a clear picture of the incurred costs linked to blackouts. Other studies show much higher losses per event:

Industry typical financial loss	per event
Semiconductor production	EUR 3,800,000
Financial trading	EUR 6,000,000 per hour
Computer centre	EUR 750,000
Telecommunications	EUR 30,000 per minute
Steel works	EUR 350,000
Glass industry	EUR 250,000

[10] http://www.leonardo-energy.org/webfm_send/2793
[11] Estimated Value of Service Reliability for Electric Utility Customers in the United States, Lawrence Berkeley National Laboratory 2009

The well known 2003 blackout in U.S. and Canada seems to be the highest economical loss ever during an outage with an estimated total cost of USD 4 bn to USD 8 bn. But even short blackouts which occur several times during a year in the U.S. sum up to an annual economic loss between USD 104 bn to USD 164 bn.

Such short term outages or even just dips in voltage seem to be harmless, however, they can have severe impacts in case production and supply chain depend on accurately synchronised production processes.

Paper manufacturing is a prominent example of such a business, but also the production of semiconductors. Apart from the reduced output and the waste of raw materials, the inability to supply the customer is critical due to the ever increasing interdependencies of supply chains.

Costs per customer differ significantly between residential, commercial, and industrial customers. The costs can be described as the Value of Lost Load (VoLL), which is the estimated amount that customers would be willing to pay to avoid a disruption in their electricity service. Highest costs accrue during the first hour and then declining slowly thereafter, but they additionally differ according to various elements:

- Industry sector
- Size of the enterprise
- Duration and frequency of past events
- Time of day and by season of the year
- Proportionate to household income

Some examples of impacts on specific industries during the 2003 blackout in U.S. and Canada.[12/13]

- **Daimler Chrysler:** lost production at 14 of its 31 plants. 6 of those plants were assembly plants with paint shops. The company reported that, in total, 10,000 vehicles were moving through the paint shop at the time of the outage had to be scrapped.
- **Ford Motor Company:** at Ford's casting plant in Brook Park, Ohio, the outage caused molten metal to cool and solidify inside one of the plant's furnaces. The company reported that a week would be required to clean and rebuild the furnace.
- **Marathon Oil Corporation's:** the blackout was responsible for triggering emergency shutdown procedures at the Marathon Oil Corporation's Marathon Ashland refinery about 10 miles south of Detroit. During those procedures, a carbon monoxide boiler failed to shut down properly, causing a small explosion and the release of a mixture of hydrocarbons and steam. As a precautionary measure, police evacuated a one-mile strip around the 183- acre complex and forced hundreds of residents to seek shelter elsewhere.
- **Nova Chemicals Corporation:** reported that plant outages resulting from the August 14 blackout reduced third-quarter earnings by USD 10 m or 12 cents per share. The power outage hit production at its Corunna, Moore Township, Sarnia, and St. Clair River, Ontario, and Painesville, Ohio, facilities.
- **Duane Reade Inc.:** the largest drug store chain in the metropolitan New York City area reported that the August 14 blackout forced the closure of all of the company's 237 stores. The company estimates that lost sales as a result of the interruption totalled approximately USD 3.3 m.
- **Airports:** were closed in Toronto, Newark, New York, Detroit, Cleveland, Montreal, Ottawa, Islip, Syracuse, Buffalo, Rochester, Erie, and Hamilton. Together they cancelled over 1,000 flights.
- **New York City:** the comptroller's office estimated that losses topped USD 1 bn, including USD 800 m in gross city product. The figure includes USD 250 m in frozen and perishable food that had to be dumped.
  The Restaurant Association calculated that the city's 22,000 restaurants lost between USD 75 m and USD 100 m in wasted food and lost business. Broadway lost approximately USD 1 m because of cancelled performances. New York City's mayor estimated that the city would pay almost USD 10 m in overtime related to the outage.
- **Financial Markets:** the lights went out after 4 p.m., which meant that the major U.S. stock exchanges had already closed – limiting the impact on financial markets. All the major exchanges and markets were up and running on Friday, but many trading companies were still without power as the trading day began.

[12] The Economic Impacts of the August 2003 blackout, prepared by the Electricity Consumers Resource Council (ELCON) – February 9, 2004
[13] http://www.policyholderperspective.com/2009/06/articles/first-party-property/2003-blackout-held-to-involve-property-damage-sufficient-to-support-claim-under-property-policy/

5. Considerations for risk management

5.1. Trends affecting the BI risk landscape and power dependency

5.1.1. GENERAL IMPACT OF BLACKOUT IN LIGHT OF CHANGED PRODUCTION PROCESSES

Manufacturers embraced "just in time" production in the 1990s, imitating Japan's auto makers. They cut stockpiles of parts and won discounts by buying more parts from a smaller group of suppliers. But that left them without a cushion of raw materials to ride out even small disruptions.

As an indicator of the above vulnerability, the Earthquake, Tsunami damage and power shortages that idled thousands of Japan's factories in 2011 highlighted its role as a key — and sometimes the only — source of auto parts, graphics chips and other high-end components. In fact, today, many manufacturers are currently using up the inventories that they had in stock before the earthquake. A similar situation could occur as a result of a larger power outage.

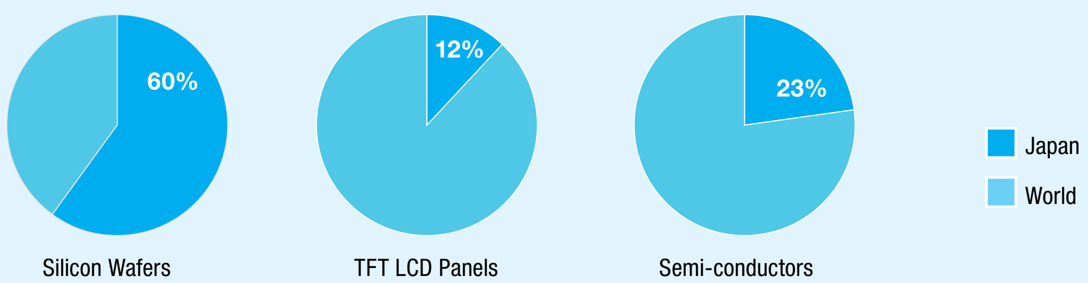
Consequences of the 2011 Japan Tohoku Earthquake for mobile phone & computers manufacturers

- **Apple:** some parts of iPad (e.g. the flash memory, the super-thin battery, the built-in compass, the glass overlaying and the touchscreen) are produced exclusively by Apple Japan. That is why Apple had difficulties obtaining these components (logistical disruptions), even months following the event.
- **Toshiba:** has shut 1 of its 2 LCD (liquid crystal display) plants to recalibrate sensitive equipment knocked out by the earthquake. Hitachi too has shut its LCD Tokyo factory because of damages and power cuts. Indeed, LCD used in mobile phones and satellite navigation may be in short supply.
- **Sony:** has shut down 5 of its 6 laptop batteries factories in Japan. Other computer-makers may be hit by shortages of these batteries.

Consequences for silicon users

Japan represents 60% of the global silicon wafer supply. The silicon wafers are used in many integrated circuits and other micro devices, which are key parts used to make a wide range of electronic equipment. Some of the biggest silicon manufacturing units in Japan have been damaged by the earthquake and tsunamis and shortages may appear in a short time. Even if there are still alternative sources for these components, alternative suppliers might also be facing shortfalls because of the increasing demand, making it difficult for the manufacturers to find supplies elsewhere.

Figure 6: Japan's shares in silicon industry (% of global suppliers)



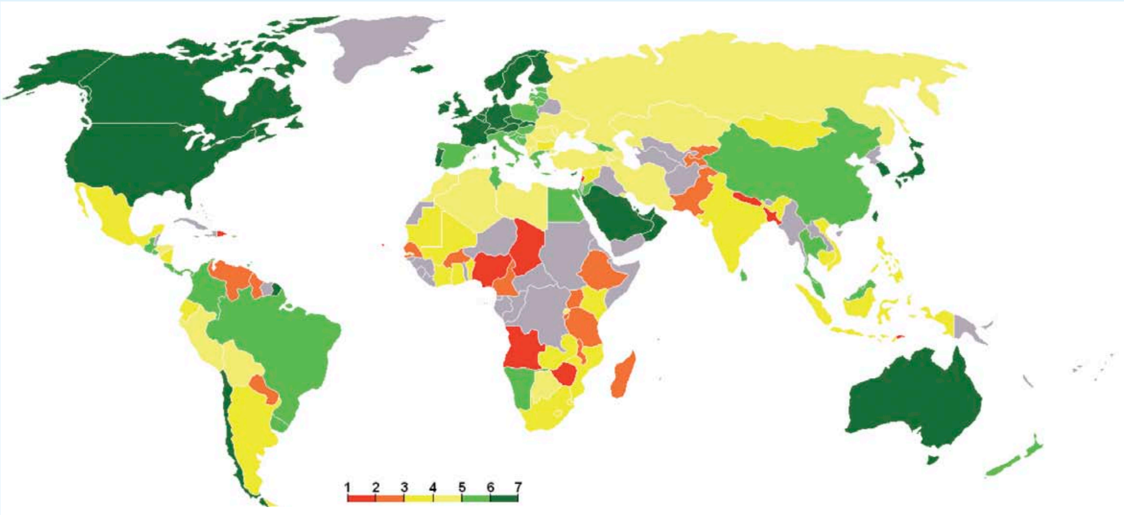
Source: IHS Global Insight

5.1.2. SPECIFIC IMPACT BASED ON CAR MANUFACTURERS

The vulnerability of automotive manufacturers to the power outages is very pronounced, as the automotive industry has been the first industry to apply just-in-time production. A long supply interruption means a significant risk of stock shortage, resulting in a high risk of production loss.

According to the site www.automotive-index.com, the majority of the automotive suppliers are still located in developed countries (Canada, Germany, U.S., etc.). However, many suppliers are also increasingly located in developing countries. The energy supply in these countries is less reliable, as can be seen in Figure 7. When comparing the map of electrical power supply by country with the map of car manufacturing (*Figure 8*) and their suppliers, it becomes obvious that the spread of locations show a significant production in countries with lower power reliability, such as Turkey, India, Malaysia and Indonesia.

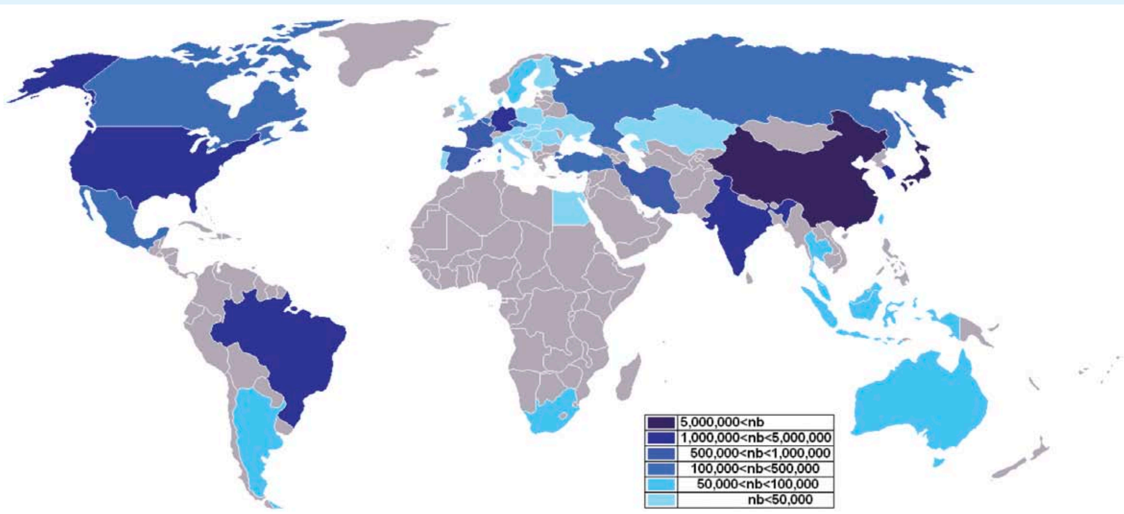
Figure 7: Quality of electricity supply by country, 2010



1 = insufficient and suffers frequent interruptions 7 = sufficient and reliable

Source: World Economic Forum

Figure 8: Number of produced cars per countries in 2009



Source: OICA

5.2. Business Continuity Planning to mitigate power blackout risks

A well organised and implemented business continuity plan (BCP) is vital for the survival of a company in case of a power blackout, as well as to gain access to insurance solutions for such risks. The holistic structure of BCP includes both a company's internal factors, such as organisation, infrastructure and information and decision-making channels, and external factors, such as technology, customers, suppliers, environment, nature and social setting.

A successful BCP bases on a risk analysis which consists of

- Risk Identification Analysis (RIA)
- Risk evaluation
- Risk mitigation/adaption
- Risk Control

Once the risks have been identified and evaluated, it is advisable to draw up a list of measures. This will show the energy company specific areas of weakness of any business interruption in a systematic way. Examples of all four risk management steps are outlined in the following table:

Figure 9: Risk Management steps incl. examples

Risk Identification			Risk Evaluation		Risk Reduction			Risk Control	
No.	**Weak point**	**Cause**	**Amount of loss**	**Probability of occurrence**	**Measure**	**Effectiveness**	**Priority**	**Costs**	**Responsibility**
1.	Power supply infrastructure of the company	Age over 60 years	Power outage of facility and production estimate: EUR 20 m a day	Twice a year	Replacement by new equipment and machines including maintenance program	Prevention of power outage	Prio 1	EUR 15 m one off costs	CEO
2.	Blackout risk of main suppliers due to dependency of public power supply	Main suppliers without own or emergency power supply	Stop of single production line EUR 10 m loss a year	Five times a year	Main suppliers install own power supply	Prevention of production stop	Prio 1	EUR 5 m to 8 m	CEO of main supplier
3.	Loss of public power grids due to wild fire	Wild fire caused by heat and drought	Power outage of facility and production estimate: EUR 20 m a day	Several times especially during the summer time	Underground installation of the high voltage power lines and additional power backup	No exposure to loss for the power lines	Prio 2	Falls under responsibility of the power supplier volunteer financing/participation of the manufacturing company	CEO of public supply company and CEO of manufacturing company

At the end of the threat analysis, the following key questions arise regarding business continuity management.

- Are the critical functions and processes in the company defined?
- Does useful documentation exist concerning frequency, scale and causes of business interruptions?
- Do comprehensive disaster recovery plans exist where the necessary strategies, data and operating resources are laid down for business recovery?
- Are the IT and communication systems sufficiently protected, so that they can resume operation within the required time following incidents?
- Are there plans which are tested and updated regularly by means of practice drills?

DESCRIPTION OF BUSINESS CONTINUITY PLANNING (BCP) ELEMENTS

Business continuity organisation

concerns all divisions of the company and requires cooperation at all hierarchy levels. Only a clearly structured business continuity organisation can ensure that strategies are developed, established, maintained and properly implemented in an emergency.

People involved in preparing and maintaining the business continuity plan need to be acquainted with the company's infrastructure and processes and suited to the tasks in question. Responsibilities within the BC process as a whole need to be clearly defined at all times.

The top position in the BC management should be held by a representative of the highest company level to ensure high strategic priority within the company. A crisis team could operate locally and objectively in the closest possible proximity to the emergency while emergency service teams were safeguarding the infrastructure and recovery teams were already starting with specific disaster recovery activities.

Business Impact Analysis (BIA)

is the cornerstone of BCP, as it forms the basis of the further recovery strategy. In order to determine the relevant business processes at risk of failure and describe them in detail in terms of their importance and impact, questions are put to the senior management. Based on the information received, an analysis is carried out to ascertain how long the company can continue to operate without its existence being jeopardised if areas identified as being at risk fail. Here, any interdependency and contingency losses arising from the power outage must also be taken into account.

The business impact analysis results in statements about:

- Loss potentials
- Restart times for critical business functions, and also
- Emergency staff, infrastructure and contingency workplaces

Disaster recovery plans

lay down, step by step, the procedure to be followed – from the alerting routine to resumption of the business function.

The result should be a group-wide business continuity guideline that defines the key data of the BCP and which the entire Board of Management approves as a binding requirement. The BC guideline will include the business continuity organisation, the business continuity master plan and all the measures for maintaining, exercising, auditing and developing the BCP.

Testing and developing the BCP

The best business continuity planning can fail in an emergency if it is not constantly adapted to current conditions and regularly practised. Tests, training, audits and simulations are the supreme discipline of business continuity planning.

Internal and external audits are also used to ensure the quality of BCP. To this end, as part of its responsibilities, the BC management checks whether the rules agreed beforehand are complied with in the individual business units and whether the BC organisation and BC set-up tally with the planning in everyday life.

As a result of the increased reduction of redundancies and the outsourcing outlined before, the BCM Manager has to include power supply as one of the business critical processes into the BCP.

This could be addressed in various ways:

- Ensure, that for business critical processes multiple sources are available
- Ensure, that the impact of a power outage is reduced by investing in technical backup units (e.g. emergency power supply)
- Ensure, that cost benefit analysis relocating or outsourcing business critical processes take the additional risk of power outages into account, which might lead to the decision to locate the process in another country than originally planned.

5.3. Risk transfer solutions

5.3.1. PRINCIPLES OF INSURABILITY

Insurance clients benefit from protection against unexpected losses and peak risks as well as freed up capital which can be deployed otherwise. The insurance industry enables therefore economic growth and innovation by reducing volatility and providing capital relief. Depending on their needs and the insurance markets' product range, coverage extent and conditions vary. In order to transfer risks to the insurance industry a set of criteria has to be considered:

- **Randomness:** The time and location of an insured event must be unpredictable and occurrence itself must be independent of the will of the insured (i.e. accidental).
- **Assessability:** The frequency that an event will occur and severity of the resulting damage can be estimated and quantified within reasonable confidence limits.
- **Mutuality:** A large number of endangered parties must join together to build a risk pool in which risk is shared and diversified at economically fair terms.
- **Economic viability:** Insurers must be able to charge a premium that corresponds to the underlying risk including capital costs and expenses.

5.3.2. CURRENT RISK TRANSFER SOLUTIONS

Therefore, blackout related risks can be separated into insurable versus not insurable risks.

Insurable

- Property damage (PD), business interruption (BI), insurance for utilities
- BI extensions insuring failure of power supply for commercial and industrial enterprises
- PD insurance for private households

Not insurable

- Unlimited and uncontrolled covers for generally insurable exposures
- Frequent losses (e.g. short term power blackouts)
- Operational risks

Electricity producers, distributors and consumers of electricity have various options to insure risks arising from power outage.

Electricity producers and distributors

Producers usually buy property damage and business interruption insurance. These covers cushion or prevent financial loss due to a reduction in turnover, if such reduction is due to material damage to insured property on the insured premises. Covered perils are fire, explosion, social perils and natural perils in fire business interruption insurance and various types of machinery failures in respect of machinery breakdown insurances.

In general, distributors of electricity have the same options for business interruption coverage as producers. Since the distribution net with its transmission and distribution lines is usually heavily exposed to natural perils such as wind, ice storm and earthquake, insurance coverage may be limited regarding both property damage which triggers BI and insured perils.

BI insurances for both producers and distributors usually avoids frequency losses by respective monetary deductions. These provide for self-insurance by the insureds in case of minor interruptions in electricity supply.

Some fairly new insurance products offer financial income protection against adverse weather conditions. These normally apply to reduced electricity consumption arising in connection with warmer than expected winter seasons, i.e. do not depend on accidental loss events. Often such covers are determined by indexes – so-called parametric covers – rather than by the actual loss sustained as is the rule in Property and Casualty insurance.

In addition, special BI extensions exist which cover financial loss in connection with failure to produce or deliver electricity following malfunction of data that was not caused by a physical loss or damage. Insured perils include, data corruption or malfunction of data due to operating errors, hacker attacks or data malware.

Consumers

Consumers range from industrial and commercial enterprises to public authorities. Industrial and commercial enterprises buy insurance against both material damage and BI due to failure of electricity. Usually for both types of covers material damage on the premises of the insured is required. Such coverage only exceptionally includes the transmission and distribution lines as the accumulation potential is considered to be high. In case the feared event does not occur at the insured's location but at a supplier's site, this type of BI extension is called dependent BI or contingent BI.

5.3.3. FUTURE RISK TRANSFER PRODUCTS

Physical damage to premises or distribution lines of electricity producers and distributors are likely to remain the main exposures. Contingent BI exposures remain the most important feature for electricity consumers. Subject to an increasing trend for electricity interruptions, consumers' preparedness to buy specific insurance coverage is likely to increase. The insurance industry may be able to include the most frequent failures due to damage to transmission and distribution lines and consequently manage the increased accumulation potential.

Nonphysical damage business interruption insurances, like coverage for fluctuations in the weather pattern, volcanic ash clouds or pandemics, will hardly become more than complementary. Reasons for this are the accumulation potential, the low number of insurers prepared to offer coverage, high premiums, scarce capacity and a small number of interested parties to buy such coverage. However, additional elements of nonphysical damage coverage may be designed to cater for specific needs of industrial and commercial clients. Perils that could suit such purpose are a lack of cooling water for power plants due to extended periods of drought or interruption of electricity production due to safety measures required by public authorities. Interruptions due to safety concerns have recently taken place in Japan as a consequence of earthquake damage to the Japanese power and distribution industry.

BI insurance not based on physical damage may, in addition, move away from the indemnity principle. Fixed sums insurances for BI loss could use parametric triggers such as the number of hours or days of electricity failure.

5.3.4. RESIDUAL RISK ACCEPTANCE

The risk that remains with the threatened subject is the residual risk. It is either not insured or not entirely insured:

- One of the main reasons for not insuring an insurable exposure is the amount of premium required for coverage.
- Insurers accept only a part of insureds' exposures. They introduce sub limits, risk or loss retentions.
- The boundaries between insurable and noninsurable risks are not clear cut. In some instances seemingly noninsurable risks can be made insurable (high risk retentions and exposure limitations). Furthermore, the insurance market is developing and extending the limits of insurability. However, insurability generally ends where the occurrence of the feared event or the date of occurrence (e.g. in life insurance) is not fortuitous anymore.

Potential insureds need to customise their insurance protection considering the above mentioned restrictions and accept some residual risk.

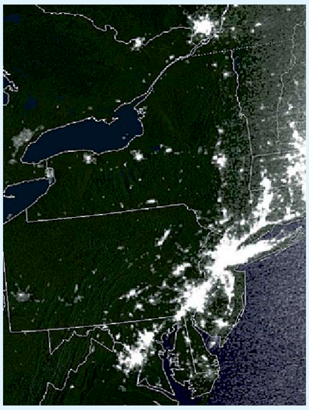
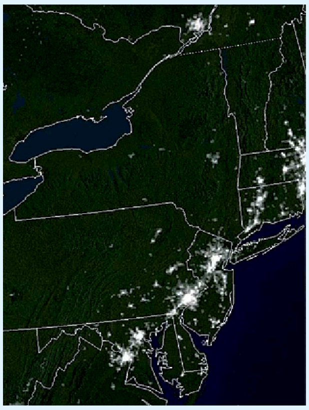
6. Conclusion

The power blackout risk is generally underestimated. Blackouts during the last ten years in Europe and Northern America have demonstrated an increasing likelihood of supra-regional and long-lasting blackouts including high economical losses. Due to the increasing interconnectedness in combination with rather old infrastructure we expect this risk to increase in both frequency and severity.

Politics have to establish clear frameworks for the governance of power supply infrastructures. This is a necessary step to enhance resilience of power grids. The main responsible stakeholders who have to take care of a reliable power supply are public and private utilities as well as system/network operators.

Insurance buyers have to be aware that they may suffer during a blackout noncovered losses which require precautions against damages. For the insurance industry this might trigger an increasing customer demand not only for power blackout risk solutions, but also for supply chain and nonphysical business interruption risks in general. It presents a great challenge, however, to handle those intangible risks while also offering a great opportunity to invest in the development of tailored insurance products (potentially combined with busines continuity management services) which fulfil customer demand and the requirements for insurability. Furthermore insurers need to review their own BCM capabilities concerning blackout risks to make sure that they can provide services even in the case of long-lasting blackouts.

When risk management is done well and risks can be reliably quantified, insurance is an important mechanism for risk transfer. All parties, insurers, electricity industry and consumers should engage in risk dialogues to proactively address and manage related power blackout risks with the aim to maintain one of the most important goods in a civilized society, a reliable supply of electricity.

Source: NOAA

Blackout 2003, U.S./Canada[14/15/16]

What happened?

On August 14, 2003, large portions of the Midwest and Northeast United States and Ontario, Canada, experienced an electric power blackout. The outage affected an area with an estimated 50 million people and 61,800 MW of electric load in the states of Ohio, Michigan, Pennsylvania, New York, Vermont, Massachusetts, Connecticut, New Jersey and the Canadian province of Ontario. The blackout began a few minutes after 4:00 pm Eastern Daylight Time and power was not restored for 4 days in some parts of the United States. Parts of Ontario suffered rolling blackouts for more than a week before full power was restored.

Causes:

The blackout had several causes or contributory factors:

- Inadequate vegetation management (line contact by trees);
- Failure to ensure operation within secure limits;
- Failure to identify emergency conditions and communicate that status to neighbouring systems;
- Inadequate operator training;
- Inadequate regional-scale visibility over the power system;
- Inadequate coordination of relays and other protective devices or systems;
- Inadequate interregional visibility over the power system;
- Dysfunction of a control area's system;
- Lack of adequate backup capability to that system.

Impacts:

In Canada, gross domestic product was down 0.7% in August, there was a net loss of 18.9 million work hours, and manufacturing shipments in Ontario were down USD 2.3 bn. The losses were mainly related to perishable goods spoilage, production and computer equipment shut down and business income losses.

In United-States, Anderson Economic Group estimates the likely total cost to be between USD 4.5 bn and USD 8.2 bn. This includes:

- USD 4.2 bn in lost income to workers and investors;
- USD 15 m to to USD 100 m in extra costs to government agencies (e.g. due to overtime and emergency service costs);
- USD 1 bn to USD 2 bn in costs to the affected utilities;
- between USD 380 m and and USD 940 m in costs associated with lost or spoiled commodities. ►

[14] U.S.-Canada Power System Outage Task Force Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations
[15] The Economic Impacts of the August 2003 Blackout, prepared by the Electricity Consumers Resource Council (ELCON) – February 9, 2004
[16] http://www.policyholderperspective.com/2009/06/articles/first-party-property/2003-blackout-held-to-involve-property-damage-sufficient-to-support-claim-under-property-policy/

The U.S. Department of Energy (DOE) has published a total cost estimate of about USD 6 bn. This number is the most frequently cited cost estimate in press coverage of the blackout.

A post-blackout study underway by CrainTech (a business news publisher), Case Western Reserve University's Center for Regional Economic Issues and Mirifex Systems LLC has produced some preliminary results based on a survey of businesses in Ohio, New York, Pennsylvania, Michigan, Wisconsin and Southern Canada. These findings include:

– A quarter of the businesses surveyed (24%) lost more than USD 50,000 per hour of downtime (i.e., USD 400,000 for an 8-hour day). And 4% of the businesses lost more than USD 1 m for each hour of downtime.
– Almost 11% of firms say the blackout will affect their decision-making with regards to either growth at the current location or relocation to another.

An important indirect—and impossible to quantify—cost of the blackout was the "cascading" consequences on regions outside of the blackout footprint created by manufacturers' just-in-time (JIT) production scheduling. Delivery times for parts and materials to assembly plants are timed to meet scheduled production and thus minimize or eliminate the cost of inventory.

On April 22, 2009, the Appellate Division of the New Jersey Superior Court published its March 9, 2009 opinion holding that the massive August 14, 2003 electrical blackout of the eastern United States and portions of Canada inflicted "property damage" sufficient to support a property insurance claim. The court held that the loss of functionality that resulted when protective safety equipment shut down the power grid and caused the blackout qualified as "physical damage" for property insurance purposes. As a result, insurers were not entitled to summary judgment in their favour on claims (e.g. for food spoilage and business interruption) resulting from the blackout.

BLACKOUT 2003, ITALY/SWISS[17/18/19]

What happened?

- 28th September 2003: Italian power system faced its worst disruption in 50 years, which also affected parts of Switzerland with 56 million people in total
- Electricity was restored after 1.5 hours (CH) and 18 hours (Italy)

Causes:

- Inability of the Swiss system operator to reclose the Mettlen-Lavorgo line after its initial failure.
- Ineffective communication and subsequent slow and ineffective emergency responses by the Swiss and Italian system operators.
- Angle and voltage instability in Italy just prior to its collapse.
- Insufficient tree cutting under the power lines.

Impacts:

- Beside Switzerland and Italy, the networks in France, Slovenia, and Austria were affected and the blackout led to a domino effect that ultimately resulted in the separation of the Italian system from the rest of the European grid. ►

[17] Project Understand, White Paper on Security of European Electricity Distribution, 20.6.2007 (http://www.understand.se/docs/White_Paper_EN.doc)
[18] http://www.solarstorms.org/Italy2003.html
[19] http://www.semissourian.com/story/121022.html

- 30,000 people were trapped on trains.
- Several hundred passengers were stranded on underground transit systems.
- Significant knock-on effects across other critical infrastructures, commercial and domestic users which suffered disruption up to 48 hours.
- Subway had to be evacuated.
- Cost to restaurants and bars in spoiled products and lost sales totalled up to USD 139 m.

BLACKOUT 2006, GERMANY INCL. WESTERN EUROPE[20/21/22/23]

What happened?

- On November 4, 2006 the German TSO E.ON Netz had to switch off a high voltage line to let a ship pass underneath.
- Simultaneously there was a high amount of wind electricity which fed into the grid 10,000 MW from wind turbines to Western and Southern Europe grids.
- Insufficient communication about this switch-off led to instabilities of the frequency in the grid and to overloading of lines.
- Devices had to switch customers off in the countries affected to cope with this lack of power in the Western zone automatic.
- The blackout lasted up to two hours.

Causes:

- After manual disconnection of the high-voltage line the n-1 criterion of process security was not fulfilled. N-1 criterion means that any component may fail and all other components are still below their limit. As a result, even a relatively small power flow deviation could trigger the cascade of line tripping.
- Insufficient co-ordination between transmission system operators.
- No access to real-time data from the power units connected to the distribution grids.
- Lack of joint simulation training with neighbouring transmission system operators.
- Lack of coordination between operators' internal procedures regarding grid-related, market-related and other adjustments.

Impacts:

- In France 5 million customers were cut-off.
- In Germany millions of customers were affected and in Belgium, Netherlands, Italy and Spain some hundreds of thousands of customers were without electricity.
- Long delays in rail transport, affecting about 100 trains mainly in Germany.
- Subway had to be evacuated.
- Costs to restaurants and bars in spoiled products and lost sales totalled up to USD 139 m.

[20] Project Understand, White Paper on Security of European Electricity Distribution, 20.6.2007 (http://www.understand.se/docs/White_Paper_EN.doc)
[21] http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/110
[22] Final Report System Disturbance on 4 November 2006
[23] http://www.worldenergy.org/focus/blackouts/393.asp

NUCLEAR CATASTROPHE FOLLOWING AN EARTHQUAKE AND TSUNAMI TRIGGERED STATION BLACKOUT, JAPAN 2011 [24/25/26]

The complete power supply cut off of the nuclear power plant in Fukushima Dai-Ichi, Japan in March 2011 led to severe damages in the reactor units 1, 2 and 3 and resulted in significant emissions of radiation into the atmosphere. The tsunami which flooded the emergency diesel generators caused the on-site power blackout so that the operator was unable to keep the cooling systems running. This power outage is a so called station blackout (SBO). The impact was tremendous:

- Fukushima is rated as serious as the Chernobyl catastrophe – magnitude 7 event, the worst on the international nuclear event scale though Fukushima released only 5 to 10% of the radiation released by Chernobyl.
- Mandatory evacuation zone for all residents within 20 km.
- Voluntary evacuation of all residents between 20 and 30 km.
- Agricultural products including milk and vegetables from the region got contaminated.
- Decades will be required for cleanup and containment.
- Estimates on reinsurers' share of losses from the Japan disaster could be between USD 20 bn and USD 30 bn out of the disaster's total gross loss estimated at USD 40 bn to USD 65 bn. These estimated losses would exceed the 20 bn to USD 25 bn in losses ceded to reinsurers from the 9/11 terrorist attacks, and the USD 18 bn to USD 24 bn incurred by reinsurers from Hurricane Katrina in 2005.

As a consequence of the earthquake and tsunami three other nuclear plants, six coal-fired plants and 11 oil-fired power plants were shut down. This is 11 percent of Japan's total power. As a consequence factories had to operate at reduced levels, which will have a significant impact on Japans' economy. JPMorgan Securities Japan estimates that the country's gross domestic product will shrink in the second quarter by about 3% on an annualised basis, with about half of that decline resulting from the power shortage.

picture alliance/dpa

[24] http://mrzine.monthlyreview.org/2011/lochbaum300311.html
[25] http://perspectives.mvdirona.com/2011/05/31/WhatWentWrongAtFukushimaDai1.aspx
[26] http://www.insurereinsure.com/?entry=3533

CRO Forum

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Swiss Re

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Group Chief Risk Officer
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The CRO Forum's Emerging Risks Initiative

The Emerging Risks Initiative (ERI) was launched in 2005 to raise awareness of major emerging risks relevant to society and the (re)insurance industry. In 2011 the initiative is chaired by Markus Aichinger (Allianz SE) and consists of nine members representing AIG, Allianz, AXA, Generali, Hannover Re, Munich Re, RSA, Swiss Re and Zurich Financial Services Group. This initiative pursues the following goals:

– Raising awareness and promoting stakeholder dialogue.

– Developing best practice solutions.

– Standardizing disclosure and sharing knowledge of key emerging risks.

CRO Forum Emerging Risks Initiative member companies:

Associated members of the Emerging Risk Initiative (not members of the CRO Forum):

The CRO Forum is supported by a Secretariat that is run by

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