Norwegian Directorate for Civil Protection

MEREPUV

2017/PREV/783153

"Methods and measures to enhance resilience against electric power outage in urban vital societal functions"

MEREPUV - Norway

Vulnerability to power outage in urban vital societal functions

Main findings from Norway based on assessments from city of Oslo, Bergen and Stavanger

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Innhold

1 Introduction

1.1 Short introduction to the MEREPUV project

Power supply is crucial in today`s society since almost all other vital societal functions rely on electrical power. Disruptions in power supply can quickly lead to chains of negative impacts or cascading effects, and thus negative consequences for citizens.

The project MEREPUV (*Methods and measures to enhance resilience against electric power outage in urban vital societal functions)* has as general objective to make cities more resilient to disruptions in power supply:

- by improving knowledge of cities` role in protecting vital societal functions from such disruptions, and
- by identifying efficient measures available at the local level for protecting citizens against severe consequences of power outage.

In addition, a set of more specific objectives has also been defined for the project. These are:

1. Improved understanding of and experience with methodological approaches for assessing vulnerability in societal functions with emphasis on interdependencies.

2. Improved knowledge of risks of severe power outage in the cities and efficient measures available at the local level.

3. Better understanding of the municipalities` role vis a vis other stakeholders` responsibilities in preventing severe consequences of undesirable incidents striking urban vital functions.

4. Closer cooperation and sharing of experience nationally and internationally between cities and national authorities in efforts aimed at improving urban resilience.

The project is partly funded by the European Commission (DG ECHO) Union Civil Protection Mechanism for prevention and preparedness projects in civil protection and marine pollution. The project partners are stakeholders from Norway, the Netherlands, and Latvia:

- Norway: Norwegian Directorate for Civil Protection DSB (coordinator), City of Oslo, City of Bergen, City of Stavanger.
- Netherlands: Safety Region South Holland-South, City of Dordrecht
- Latvia: State Fire and Rescue Service, City of Valmiera

The focus in MEREPUV has been on vulnerability of disruptions in power supply within the three other vital functions health services, emergency services and electronical communication services. The five cities participating in the project have all conducted an assessment focusing on loss of electrical power supply as the adverse event. Each city has assessed direct and indirect consequences for one of the other vital societal functions mentioned, and documented the findings in five English summaries.

The partners from each of the three participating countries have summarized the findings in three country reports. These reports, together with the cities summaries, will be used to document the overall results of the project in a final report, whose purpose will be to share the gained knowledge with other participating states of the UCPM / European cities.

Knowledge building project - joint methodology

MEREPUV has been a knowledge-building project and the partners have used the same methodology in their analytical process.

The chosen method builds on the so-called bow tie model, and is adapted and specified on basis of purpose of this project and the main questions to be examined by the five cities. The chosen method is also scenario based, where a set of scenarios have been used as stressors for examining vulnerabilities. The following main elements have been emphasized in the cities assessments:

- Assessment of how the scenarios affect critical input factors for health / rescue / electronical communication services
- Assessment of the overall impact of the scenario on health / rescue / electronical communication services, directly due to the power outage, and indirectly due to disruptions in critical input factors
- Assessment of how disruptions in health / rescue / electronical communication services affect other vital societal functions. Cascading effects
- Assessment of overall consequences of disruptions in health / rescue / electronical communication services on the societal values "life and health" and "social stability"

The partners agreed on two joint scenarios of electrical power outage to be assessed by all the five partner cities. The further specification of the scenarios was up to each partner country.

- Scenario 1: loss of electric power for 24 hours
- Scenario 2: loss of electric power for 72 hours

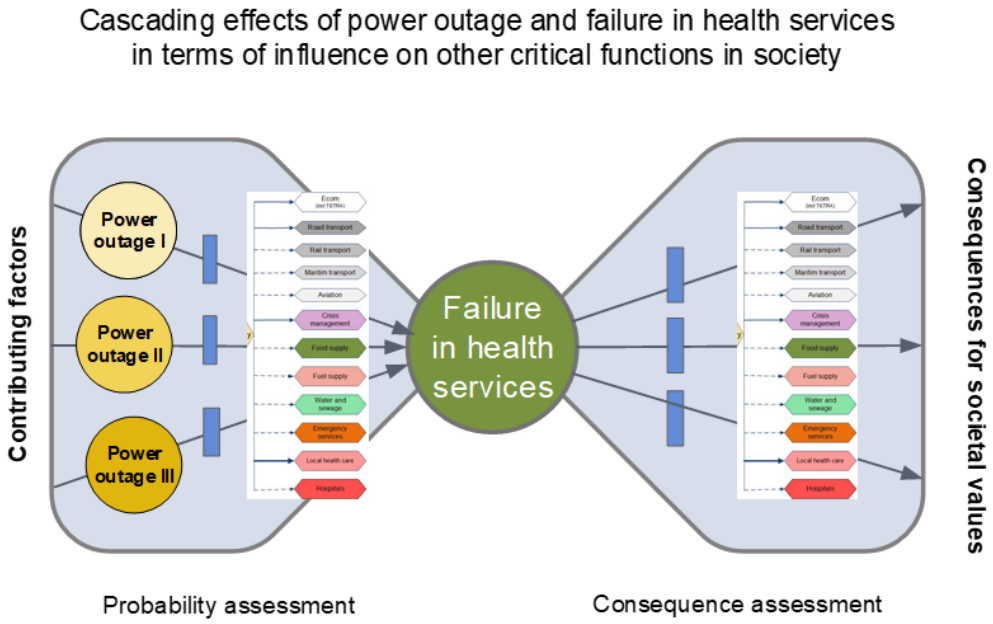

Figure 1. Risk and vulnerability assessment in four steps: 1) How do the scenarios affect other vital functions? 2) How does failure in such vital functions affect health services? 3) How does disruption in health services affect other vital societal functions (interdependencies) 4) What are the consequences for citizens and society?

A joint understanding of the term "vital societal function" has been important for the project, and the following definition has been used in MEREPUV:

"A vital societal function is a function of such importance that its loss or severe disruption could entail major risks for the life and health of the population, the functionality of society or society's fundamental values."

Furthermore, the Norwegian framework "Vital functions in society"[1] has been introduced to the partners as an illustration of the Norwegian approach to identification and operationalization of vital societal functions. In Norway, 14 such functions are identified as vital. "Power supply", "rescue services", "health and care" and "electronic communication network and services" represent four of the functions defined as vital in the framework. Each of the 14 vital functions are further broken down and detailed into capabilities. A more detailed description of the chosen methodology and vital functions and capabilities in the Norwegian framework, can be found in annex 1 and annex 2.

1.2 About the Norwegian part of the MEREPUV project

Scenarios

The scenarios agreed upon by the Norwegian project are briefly described in the table below. The city of Oslo has assessed consequences of the scenarios of power outage on rescue services, the city of Bergen consequences for health services, and city of Stavanger consequences for electronic communication services.

Description
Scenario 1 Electrical power outage 24 hours - Sunday night 29 December 2019 the electrical power suddenly disappears in the City of Oslo / Bergen / Stavanger. The power outage affects all citizens in the municipality. It is cold outside with temperature between -5 and 0 degree celsius. After 24 hours all citizens have regained access to electrical power.
Scenario 2 Electrical power outage 72 hours - At 1900 o`clock Wednesday 9 January 2019 the electrical power suddenly disappears in the City of Oslo / Bergen / Stavanger. The whole muncipality are without power until 1900 o`clock Saturday 12 January. It is cold outside with temperatures between -5 and 0 degree celsius.
Scenario 3 Electrical power outage for one week - Tuesday morning 15 January 2019 the electrical power suddenly disappears in the City of Oslo / Bergen / Stavanger. The citizens in the municipality are without electrical power until Monday morning 21 January. It is cold outside with temperatures between -5 and 0 degree celsius.

Defining rescue, health and electronical communication services, critical input factors and cascading effects

The Norwegian project has used the Norwegian framework mentioned above actively during process in order to:

- define which capabilities to include in when referring to "health services", "rescue services" and " electronical communication services"
- identify interdependencies between power outage and critical input factors for health / rescue / electronical communication services
- identify interdependencies between disruptions in health / rescue / electronical communication services and other vital functions.

[1] DSB 2017b

Involvement of stakeholders and consultations

Broad involvement of stakeholders at different administrative levels has been an important objective for the project. Directorates and agencies at the national level have contributed to the project by sharing of their expert knowledge. They have also been invited to comment on the summaries of the cities assessments and the Norwegian Working Paper before finalizing these reports. An overview of involved stakeholders at the national level is given in annex 3.

The cities have also involved several important stakeholders from regional and local level in the work with their vulnerability assessments. Amongst others, the cities have arranged four expert seminars each, in order to collect data and expert knowledge. The cities have been responsible for ensuring that involved local stakeholders have had the opportunity to read and comment on the summaries before finalization.

Structure of the Norwegian working paper

This Norwegian working paper sums up the main findings of the Norwegian part of the project, with reference to the three Norwegian cities' assessments. The paper is structured as follows: chapter 2 gives a description of the Norwegian power system together with a rudimental expert evaluation of the probability of the three scenarios to occur in a Norwegian city. Chapter 3 gives a short description of the municipalities` roles and responsibilities for prevention and preparedness in Norway. Chapter 4 summarizes the main findings from the three vulnerability assessments from Bergen, Stavanger and Oslo. Chapter 5 aims at interpreting the findings from the cities in a wider context as well as outlining the overall findings from the Norwegian project as a whole. The final chapter 6 in the report, briefly describes how the findings from Norway will be shared and disseminated.

2 Background – The Norwegian power system

Norwegian households have among the world`s highest consumption of electrical power, and electrical power is to a much larger extent than other countries, used as source for heating, light and hot tap water in buildings, as well as to operate electrical devices . Stable supply of electrical power for end users is thus crucial for civil protection in Norway, and the society`s expectations of the security and continuity of power supply is increasing.[2]

2.1 Scenarios in MEREPUV – how likely in Norway? The Norwegian power system

The security in electricity supply in Norway is evaluated to be very high. The Norwegian Water Resources and Energy Directorate (NVE) estimates the probability for all the chosen scenarios in MEREPUV to be very low for all the three Norwegian cities. Still, it is impossible to exclude the possibility that extensive power outage can occur.

2.1.1 Production of power and the Norwegian electricity grid

The Norwegian power grid is a monopoly and regulated by the state. The Norwegian Water Resources and Energy Directorate (NVE) regulates the system and grants licences for transmission and production of renewable energy.[3]

In contrast to European power systems dominated by thermal power production, 96 % of the Norwegian electricity production comes from hydro power. Norway is one of the world`s largest producers of hydro power and the public owns around 90 % of the production capacity.[4]

The Norwegian production capacity is flexible in the sense that water can be stored in reservoirs or artificial lakes. Power can thus be produced in dry periods with little rainfall, as long as there is water in the reservoirs. Norway has half of Europe`s hydro reservoir capacity.[5] Norway is also part of the European electrical power market, which enables import and export of power. Wind power currently accounts for a relatively modest share of the production capacity but dominates new investments, and production is expected to increase[6].

A secure electricity grid with sufficient transmission capacity is a pre-condition for high security in supply of electricity. The geographical distance between power production and consumer can be quite long in Norway. Thus, the electricity grid must be able to transport electrical power over long distances. In the planning and dimensioning of the electricity grid, Norway also faces challenges related to topography and areas highly exposed to weather events.

[2] Meld. St. 25 (2015-2016): s 8, OED 2015: s 34, 35, 43
[3] NVE 08/2018
[4] OED 2015:s 9, 18, 20, DSB 2016b: s87, https://energifaktanorge.no/norsk-energiforsyning/forsyningssikkerhet/,
[5] https://energifaktanorge.no/norsk-energiforsyning/kraftforsyningen/, Statnett 2014: s 21
[6] NVE 08/2018

The Norwegian electricity grid consists of three levels: the transmission grid, the regional grid and the distribution grid. Most consumers are connected to the regional and distribution grids. Statnett is the Norwegian transmission system operator, and owns around 90 % of the transmission grid. Approximately 130 different distribution system operators (DSOs) operate the regional and distribution grids. The distribution grids are mostly owned by municipalities and county councils. NVE defines annual allowed income for each of the electricity grid operators.[7]

2.1.2 Security in electricity supply – short description of roles and central regulations

In Norway security in electricity supply is defined as the power system`s ability to continuously deliver power of a given quality to end-users.[8]

The Norwegian power sector is subject to extensive regulation in all of the value chain from production, transmission in the different levels of the electricity grid, and all the way to the end user. The regulations are amongst others aimed at contributing to an efficient administration of the energy resources and to ensure secure electricity supply.[9] The Norwegian energy Act[10], the Water Course Act[11] and the Norwegian Electricity Audit Act[12] are the most important laws in this regard.

NVE lies under the Ministry of Petroleum and Energy, and bears the overall responsibility for maintaining national power supplies. NVE is licensing authority and process licence applications for construction of power plants, dams and other installations in the water courses. They also process licence applications for major power lines and other energy installations that require permission according to the Norwegian energy Act.

DSB lies under the Ministry of Justice and Public security, and is the national authority for electrical safety in Norway. DSB administers the Norwegian Electricity Audit Act with affiliated regulations. Amongst others, the law contains regulations about technical security and safety of relevance for building, operating and maintaining high and low voltage installations. The law is thus important also for security and continuity in power supply.[13]

Both NVE and DSB are audit authorities with stakeholders within the Norwegian power sector, and the directorates collaborate closely in areas where their responsibilities are tangent to one another.[14]

The Norwegian power supply is based on the n-1 criteria. This means that the electrical grid and installations related to production of power must be operated in a way which ensures that no error in a single component can cause outages to an end user. However, it is not an absolute requirement that all spots in the electrical grid have n-1 supply. Decisions regarding new investments must also be made on basis of assessments of cost benefit-efficiency.[15]

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[7] NVE 08/2018, OED 2015: s 21
[8] Meld. St. 25 (2015-2016): s 42
[9] DSB 2016 b: s88, OED 2015: s 9
[10] Lov om produksjon, omforming, overføring, omsetning, fordeling og bruk av energi m.m (energiloven)
[11] Lov om vassdrag og grunnvann (vannressursloven)
[12] Lov om tilsyn med elektriske anlegg og elektrisk utstyr (el-tilsynsloven)
[13] DSB 2016b: s87, OED 2015: s 7,18
[14] DSB 2017a: s 50
[15] NVE 2018 / 60: s 37, Meld. St. 25 (2015-2016): s 183

When power outages occur, the severity of the outage depends on it`s duration. NVE has developed a system called KILE[16], which gives financial incentives for the system operators to prevent long lasting power outages.[17] Furthermore, NVE has the responsibility to coordinate preparedness planning, and shall manage national supply of power during adverse events. NVE has developed a nation-wide preparedness organisation for this purpose consisting of stakeholders in the sector, such as producers of power, operators of transmission and distribution grids etc.[18] NVE also has the mandate to implement power rationing in situations where available energy in hydro reservoirs or through import is not sufficient to cover the consumption in the mid- to long-term.

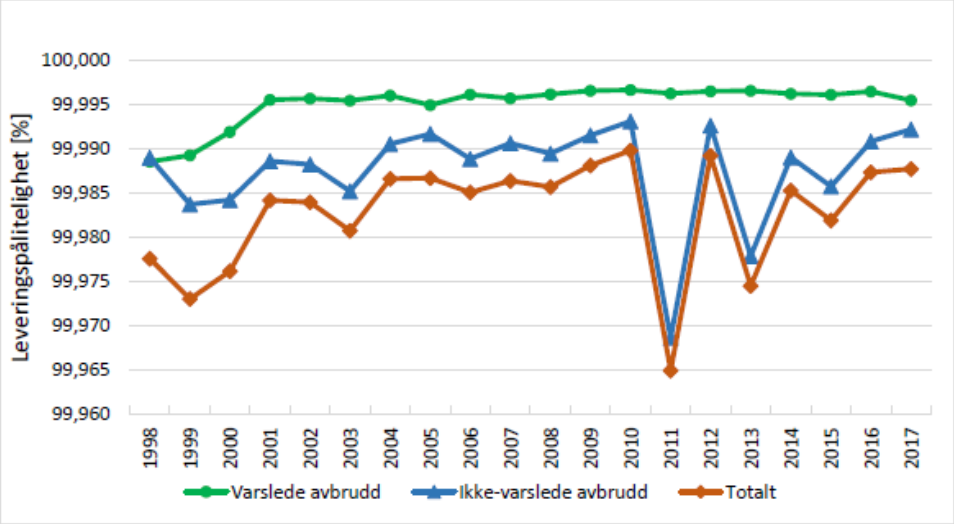
Even though many barriers are established to prevent and limit consequences of power outage, still an important principle is that absolute security against power outages cannot be achieved. This is amongst others evident in the Proposition about changes in the Norwegian Energy Act (2008-2009).[19] It is stated that a 100% guarantee of supply of power would barely be technically possible, and it would be extremely expensive for the society. The proposition concludes that those who are critically dependent on power are responsible for ensuring power back up systems with sufficient capacity.[20]

2.1.3 Continuity of supply

Norway enjoys high security of electricity supply and the continuity of supply is close to 99,99% in years without extreme weather events. Consumers in Norway experience on average about two short interruptions and two long interruptions per year. The average duration is less than two minutes for short interruptions and around two hours for long interruptions. However, the security of supply varies from region to region, and is generally better at higher grid levels.[21]

Extreme weather events in the regions affect the statistics for continuity of supply at national level. Examples of this can be seen in NVE`s figure 2 below, in the period 2011-2015.[22]

[16] Kvalitetsjusterte inntektsrammer ved ikke levert energi (KILE)
[17] NVE 2018 / 60: s 4
[18] Kraftforsyningens beredskapsorganisasjon (KBO)
[19] The largest of the two chambers in the Norwegian Parliament
[20] Ot. Prp. nr. 62 (2008-2009): s 15
[21] NVE 08/2018
[22] NVE 2018/ 60: s 4, 7, DSB 2016b): s 89



Continuity of electricity supply, Norway 1998-2017. Percentage.

Green = notified disruptions

Blue = non notified disruptions

Red = total

Figur 2: Leveringspålitelighet[6] for årene 1998-2017 (langvarig avbrudd > 3 minutter).

Overturned trees on power lines are among the most common causes of power outages with longer duration in Norway. Statistics also show that this is not only a challenge during extreme weather events, but also in years with normal weather, where snow and strong wind has to be expected.[23] Other causes can be related to outages in power lines caused by damaged ground cables due to digging (and crane) activity, slides or fallen pylons. Non notified disruptions can also be caused by maintenance taking place simultaneous to other incidents.

In addition to extreme weather events, NVE sums up the following causes as candidates that theoretically may cause severe and long lasting outages:

- *Technical failure of transformers*
- *Years with drought*
- *Solar storms / dangerous space weather*

2.1.4 Scenarios in MEREPUV – comparable events in Norway?

In Norway, there are few examples of long lasting, extensive power outages in cities. NVE does not know of any incidents where Norwegian cities have been affected by power outage to the extent suggested in the scenarios in MEREPUV. Some examples of earlier events of power outage in Norway are listed below.

The storm Dagmar 2011 (also called Patric)

The storm Dagmar hit Norway night to 25 and 26 December 2011, causing high numbers of errors and failures in the electricity grid many places in Norway, leading to the immediate loss of power for many consumers. For the most heavily affected municipalities, examples of cascading effects due to the power outage were related to disruptions in landline telephone and internet, problems for health care services, water and sewage, fuel supply, crisis management and rescue services.

- 125 139 consumers were without electrical power for more than 12 hours.
- 35 639 consumers for more than 24 hours

[23] NVE 2012 /45: s 3

- The number of persons affected by the power outage is approximately 2,3 times higher than the number of consumers.[24]

Steigen municipality 2007
25-30 January 2007, a long lasting power outage due to extreme weather stroke Steigen, a small municipality in the county of Nordland. Steigen municipality experienced many of the same cascading effects as during Dagmar, and old and vulnerable people both in institutions and private residences needed more help as a consequence of the power outage.[25]

Fire in a cable culvert at Oslo Central Station 2007
In November 2007, a combination of failure due to constructional work in a ditch with high voltage cables, and fire in a culvert in the same area, lead to the cut off of all power supply to Oslo Central station. The station had to be evacuated and all train traffic were halted for around 20 hours, affecting approximately 80 000 travellers. The event also affected around 25 000 internet customers in addition to phone customers.[26]

2.1.5 Scenarios in MERPUV – conclusion

The security in electricity supply in Norway is evaluated to be very high. The Norwegian Water Resources and Energy Directorate (NVE) estimates the probability for all the chosen scenarios in MEREPUV to be very low for all the three Norwegian cities. Still, it is impossible to exclude the possibility that extensive power outage can occur.

A relevant question is if developing trends are expected to affect the probability of severe power outages in the longer run towards 2050. The Norwegian energy report from the Norwegian Cabinet to the Norwegian Parliament 2015-2016, concludes that uncertainty is high when trying to predict on basis of such developing trends. One example is climate change. On the one hand, it is assumed that climate change may have a positive impact on security in supply due to increased power production. On the other hand, it is assumed that climate change may represent more challenges for operational security of the power system as a result of increased strain due to more weather events.[27] The report concludes that it is necessary to build a broad knowledge base that allows for sufficient flexibility that can enable society to meet a broad set of possible future scenarios.[28]

2.2 Consumers of electrical power - requirements of preparedness in case of outages

Since it is impossible to completely exclude the probability of disruptions in power supply, it is crucial that users who are critically dependent on access to power at all times, ensure preparedness measures, such as alternative source of electrical power. Hospitals, health institutions and vulnerable

[24] NVE 2012:3: s 8, DSB 2012: s 80-81
http://www.hioa.no/extension/hioa/design/hioa/images/sifo/files/file79978_presentation_dagmar_homerisk_kick-off.pdf
[25] Norconsult 2014: s 11, 12
[26] https://www.tu.no/artikler/politiet-2006-strombrudd-lite-sannsynlig/323707
DSB 2008
[27] Meld. St. 25 (2015-2016): s 174
[28] Meld. St. 25 (2015-2016): s 170

groups living in their private residences, are examples of such users critically dependent on stable access to electrical power.[29]

Public authorities have repeatedly underlined that enterprises and services must assess their own vulnerability to power outage, and implement necessary measures for self-preparedness, such as for instance power back up solutions. Still, experience from previous events and exercises shows potential for improvement in this regard.[30]

Below we briefly describe some regulations of relevance when discussing requirements for back up solutions in case of power outage in various services and enterprises.

2.2.1 The Electrical Supervision Act[31] - with affiliated regulations

In regulations related to this act it is stated that the owner and the user are responsible of ensuring that their electrical installations are in accordance with the relevant legal requirements. It is also stated that implementation of a safety power service system must be assessed wherever interruptions in the electrical power supply may cause loss of lives for persons or animals. In the guide to the regulation, hospitals, bigger hotels, institutions and private residences where life supporting electro medical devices are in use, are mentioned as examples where safety power services should be implemented.[32] For certain medical locations in hospitals, there are also detailed specific instructions on how safety power services shall be dsigned.[33]

The Norwegian Electrical Supervision Act[34] also requires that Norwegian grid operators shall carry out inspections and audits with low voltage electrical installations within their area of supply[35]. This is a specific system for Norway, called the Local Electrical Supervision Authority (DLE). DLE can carry out inspections in private residences, municipal and state services, as well as private enterprises. Annually, DLE conducts around 150 000 inspections and audits. The DLEs lie under the grid operators, but are instructed by DSB and financially managed by NVE.[36]

DLE uses risk assessments, a classification system as well as annual instructions from DSB, when defining objects to be prioritized for audits and inspections. In DSBs instructions for DLE, national, municipal and private health institutions are highlighted as services to be prioritized by DLE. Preparedness efforts related to power outage are among the check points that DLE can chose to examine during audits and inspections. DSB audits DLE, and also carries out audits in hospitals with high voltage licence.

[29] Ot.prp. nr 62: (2008-2009): s 15
[30] NVE 2012:03: s 14-16, NVE 49/2014, DSB 2018a), DSB presentasjon fagseminar MERPEUV aug 2018, NVE presentasjon fagseminar MEREPUV aug 2018, DSB 2013a,
[31] Full name of the law: The Norwegian Act relating to Supervision of Electrical Installations and Electrical Equipment
[32] DSB 2017a), Forskrift om elektriske lavspenningsanlegg §§ 9, 16, 31, veiledning
[33] NEK 400 – 5 – 560, NEK 400 – 7 - 710
[34] Se også Forskrift om det lokale elektrisitetstilsyn og sakkyndige som utfører oppgaver for netteier
[35] DSB 2017a
[36] DSB 2018c), DSB 2019d), DSB/NEK 2016/1

2.2.2 Sectoral regulations of self-preparedness in case of electrical power outages

A recent project on electrical safety has concluded that there are considerable variation between different sectors when it comes to legal regulations and audit mechanisms in order to prevent adverse consequences of power outage.[37]

This also seems to find support in the MEREPUV project. Several stakeholders have been involved during the data collection in the project, including agencies at the central level. Involved national agencies have contributed with information about central legal regulations and audit systems of relevance within their areas of responsibility. Such sector regulations comes in addition to the already above-mentioned regimes of DSB. A brief summary of such sectorial regulations is given in the table below.

Service	Regulation	Control mechanism
Electronic communications	Detailed requirements for minimum power backup capacity for base stations are laid out in the Decision on minimum requirements for backup power capacity in land-based mobile networks (reservestrømvedtaket) of 2014, with a legal basis in the Electronic Communications Act § 2-10.[38]	The Norwegian Communications Authority (Nkom) carries out audits and supervision of electronic communications providers with reference to the Electronic Communications Act § 10-1 and § 10-3. In due course, the Authority will also have a responsibility for audits and supervision in the electronic communications sector under the National Security Act. Audits and supervision include verification of power backup capacity.
Fire and rescue	The call centers and fire and rescue services must be operational at all times.[39]	DSB is auditing authority for fire and rescue services / fire call centers in Norway[40]. Consequences of power outage has been of the topics examined during audits towards fire call centers. This has not been an explicit topic in audits towards fire and rescue services.
Health services	All health services must be able to continue and if necessary expand their services during crises situations.[41]	The Norwegian Health Audit and the County Governor (Chief county medical officer) audits health services.
	Regulations on safe use and maintenance of electrical-medical devices.[42]	The Norwegian Medicines Agency has recently taken over the responsibility for this area from DSB, including the responsibility for audits.
Police	The Norwegian National Police Directorate has the overall national responsibility for police	The police works continuously with police critical infrastructure and preparedness.

[37] DSB 2017a): s 82

[38] Innspill fra NKOM 14.06.2019, Post og teletilsynet 6.juni 2014 (Reservestrømsvedtaket), Presentasjon fra NKOM i MERPUV fagseminar 28.august.

[39] Brann og eksplosjonsvernloven §§ 16, 9. Dimensjoneringsforskriften §§ 4-5, 4-7, 4-8 og 6-3

[40] Brann og eksplosjonsvernloven §§ 31a, 16, 9

[41] Helseberedskapsloven § 1-1. Se også §2-1

[42] Forskrift om håndtering av medisinsk utstyr §§ 7-12, 18

	preparedness, including requirements for back-up systems for the police emergency operation centers.	Information are often not open for the public, and can be classified.
Nødnett (TETRA network in Norway)	Detailed requirements in contract with Motorola about minimum power back up capacity in base stations and transmission lines built for Nødnett.[43] Furthermore, the backup power has been improved compared to what the Nødnett-contract originally specified.	
Water supply	Regulations about reliability in supply towards public and private water. In guidance material emergency power is mentioned and required if the water work is dependent on power.[44]	The Norwegian Food Safety Authority carries out audits related to regulations on security of water supply. Preparedness measures in case of power outage can be topic in audits, in ex this was the case in 2016.
Power plants and power grid	Power plants and substations in the grid are classified based om importance, and all important stations are required to have back up for their own power supply. The capacity and redundancy of the required back-up is dependent on the importance of the station.[45]	NVE carries out audits related to regulations for preparedness in the power sector.

[43] DNK 2014, Presentasjon fra NBK fagseminar 28. august 2018
[44] Presentasjon fra Mattilsynet i MEREPUV fagseminar 28. aug 2018, Drikkevannsforsrkfiten § 9
[45] Kraftberedskapsforskriften https://lovdata.no/dokument/SF/forskrift/2012-12-07-1157

3 Municipalities` responsibilities for prevention and preparedness

In Norway, the municipalities play a central role in civil protection. The municipalities are responsible for developing safe and robust local communities, for protecting the population, and for helping to maintain vital societal functions. This role is given through the regulation on municipal preparedness.

Duty of Municipal Preparedness
In accordance with the regulation on municipal preparedness, the municipalities shall integrate civil protection as a part of day-to-day activities in all relevant sectors, and follow a holistic approach for civil protection. The provisions also clarify the role of the municipalities as local coordinators in civil protection. This implies that municipalities should enhance:

- comprehensive and systematic civil protection
- a cross-sectorial perspective
- cooperation with other civil protection stakeholders

An essential part of the duty of municipal preparedness, is the development of a holistic risk and vulnerability assessment. The provisions on municipal preparedness provide minimum requirements to such assessments, such as the inclusion of challenges relating to critical societal functions and failures in critical infrastructure.

Due to its coordinating role, the municipality is imposed to take a leading role, inviting other civil protection stakeholders to participate in the process, to provide input for the assessment, and to make use of its results.

The holistic risk and vulnerability assessment should be followed up in an overall plan for civil protection, as well as a comprehensive contingency plan.

The aim of the duty on municipal preparedness is to ensure that the municipality:

- protects the population and helps maintain vital societal functions
- provides an overview, knowledge and awareness of civil protection challenges and the impacts these will have on population and local communities.
- reduces risk and vulnerability through preventive work.
- ensures good preparedness and crisis manageability.
- ensures cooperation and coordination with internal and external civil protection stakeholders in the municipality.

Prevention and preparedness requirements towards municipalities in sector laws
In addition to the coordinating role on civil protection, the municipality has the responsibility for civil protection in several other sectors, such as health and care, social services, fire and rescue services, acute pollution, planning and land use management, etc. There are also requirements for civil protection in services, in which the municipality can be the owner. This includes services such as schools and kindergartens and water supply. Further, there are several other stakeholders which are of crucial importance for the municipality's civil protection, such as energy and grid companies, dam owners, providers of telecom services, emergency medical services and hospitals, the police, etc. Emergency planning requirements are given in specific legislation for these stakeholders. The municipality, as coordinating body, will facilitate cooperation with and between them.

4 Identified findings and vulnerabilities from the city assessments

As earlier mentioned, each of the Norwegian cities have conducted one vulnerability assessment each of how power outage is expected to affect one other vital societal function. Bergen focused on impact for health services, Stavanger examined impact on electronical communication services and Oslo has assessed impact on rescue services.

In general, an overarching result is that although highly unlikely, a long lasting power outage in cities would have considerable impact on all societal functions examined in this project, as well as on others. In sum, this could also affect life and health of citizens. All the Norwegian cities conclude that the uncertainty related to their assessment is high, and that they have explored limited elements of the overall effects of power outage on society. Still, the assessments have revealed several vulnerabilities and interdependencies.

In the following a brief summary of the main findings from the cities work is given.

4.1 Bergen – vulnerabilities related to power outage in health services

In Bergen the following findings have been identified:

- Even if a long lasting city wide power outage is considered exceedingly rare, the consequences will be of such severity that several additional risk reducing barriers are needed to ensure the necessary resilience and function in the health care services.
- Whilst the specialist health care services are reasonably resilient in regards to power outages, the municipal healthcare services have a larger degree of vulnerability, increasing the less acute their service provisions are.
- There are some blind spots between the specialist health care services and the municipality health care services with regards to their responsibility of patients impacted by a power outage in their own homes.
- The necessary continuous fuel supply for electric generators is the major vulnerability with regards to the overall resilience towards a city wide power outage.
- The most severe consequences of a power outage in the health care services are expected to occur within the first 72 hours of a citywide power outage.

The identified vulnerabilities are as follows:

- *Communication between different health services:* Ordinary communication, coordination and control in and between the different health services are mainly based on ICT tools and telecommunication, and will be reduced or lost in a power outage, concurrent with an expected increase in the need for effective communication. Although backup-systems exist, these are not expected to meet the increased demands.
- *Public ability to contact health service:* As with the above, communication between the public and the health care services is mainly based on ICT tools and telecommunication. Few or no backup systems exist readily available in the public, leaving the public unable to contact the health care services.
- *Dependency on electro medical devices*: Home nursing patients depending on life supporting electro medical devices have few efficient barriers to be able to cope with electrical outages lasting longer than hours. Said patients are supplied with the equipment through the specialist health services, but are mainly seen on a day-to-day basis by home nursing staff.

The operational limits (battery life) for the safe use of each patients equipment is insufficiently communicated between the services, resulting in an expectation that not all patients will receive appropriate and timely intervention in case of a long-lasting power outage.

- *Health care services dependency on wireless technology:* Health care services have to a large degree replaced regular visits from health care personnel with different forms of wireless technology such as personal safety alarms, which is expected to lose functionality in a long lasting power outage.
- *Dependency fuel supply*: Healthcare buildings that are equipped with generators will be dependent on steady resupply of fuel and maintenance to ensure continued and safe core functions. Infrastructure remaining in operation during the longer scenarios will be dependent on steady resupply of fuel and maintenance to ensure continued functions.
- *Dependency on charging possibilities for cars:* The majority of municipal service cars (approx. 80%) is expected to be unavailable due to loss of charging possibilities in a power outage lasting longer than 24 hours. Home nursing and other services will need to reduce service or find alternative transports.
- *Access to potable water will vary* across institutions dependent on elevation level.

4.2 Stavanger – vulnerabilities related to power outage in electronical communication services

In Stavanger the following findings have been identified:

- The most critical input factor for electronical communication is power supply. Hence, a scenario with power outage will have major impact on electronical communication services.
- Electronical communication services is crucial in today`s society. Almost all other vital societal functions rely on electronical communication services, and disruption can quickly lead to cascading effects and severe consequences for citizens.
- There is a need for increased awareness both within companies responsible for critical tasks, and among stakeholders who must collaborate to handle long-lasting events with potential to affect the whole society.
- Stakeholders must have knowledge of how an outage in electronical communication services will affect their ability to perform tasks. Furthermore, it is crucial that necessary measures to reduce vulnerability are implemented, and that stakeholders have a plan for how to handle the situation. The scenarios described in this analysis will affect the entire community and require a great deal of interaction. Good collaboration is crucial, both in the planning and handling phase. The cooperatives must use alternative communication solutions, with other limitations and possibilities than they are used to (such as satellite radios), or meet face to face to exchange information, coordinate and interact.
- More and more services and functions are being digitized and units are connected online (IoT). Welfare technology is an example of this. Innovation and development of new services are largely based on support from telecommunications, which makes the society's dependence on electronical communication services even stronger.
- The work with this assessment has made the City of Stavanger more aware of what can happen in case of an outage of power and electronical communication services. Because of this, long-lasting loss of power and electronical communication services will be highlighted in the revised risk and vulnerability analysis

- The assessment has revealed several measures and topics that need to be followed up. The City of Stavanger will initiate follow-up projects and invite relevant stakeholders to participate. Several of the identified measures are applicable for other departments, stakeholders, companies and municipalities. The City of Stavanger has developed a plan for dissemination of the results to other cities and relevant stakeholders.

The identified vulnerabilities are as follows:

- *Knowledge and awareness regarding outage of power and electronical communication services*: Too low knowledge and awareness related to which consequences outages in power and electronical communication can have for different stakeholders and businesses
- *Alternative communication solutions*: A power outage will affect commercial electronical communication services to a very large extent. This addresses the need for alternative communication solutions
- *Information to the citizens:* In the event of an outage in electronical communication services, it will be challenging to provide information to the citizens
- *Cooperation:* 2-4 hours after loss of power, most of commercial electronical communication services will be unavailable. This will make the handling of the situation challenging and addresses the need for co-location for stakeholders who need to collaborate.
- *Dependency fuel services:* In case of a power outage, many stakeholders depend on fuel supply to maintain vital societal functions.

4.3 Oslo - vulnerabilities related to power outage in rescue services

In Oslo the following findings have been identified:

- Long lasting power outages will cause loss of electronical communication. The citizens will then have difficulties to make contact with the rescue services. The rescue services will have to reassign their resources to reinforce the operational personnel and equipment to increase detection capability, and enhance communication and accessibility for citizens. The analysis also underlines the need for the municipality to provide predefined locations where the municipality and the rescue services can provide information to the citizens, and to make the citizens able to reach the rescue services.
- The rescue services communication system, TETRA/Nødnett, makes it possible for the rescue services to communicate even during power outages and loss of commercial electronical communication services. TETRA/Nødnett is to some extent dependent upon the commercial networks, but have better emergency power. TETRA/Nødnett can also be used in "Direct Mode Operation", and emergency services can then communicate directly with each other and do not rely on network. The ability to communicate will be even more important with reduced detection capability due to power outage.
- The rescue services all need to be mobile to be able to reach out to the citizens. A long lasting power outage will affect traffic systems and normal fuel supply. There is limited experience and knowledge about how this will affect the rescue services' accessibility.

The identified vulnerabilities are as follows:

- *Importance of emergency power and redundancy emergency center*: Both the rescue services and their emergency centers are highly dependent on functioning emergency power if the normal power supply fails. During regional crises it might be necessary to draw on recourses

from other districts, but there is no redundancy on the 110 emergency center for connection calls to other 110 centers.

- *Dependency of fuel supply*. The rescue services is dependent on fuel supply to maintain mobility. The rescue services do not have much own local storage of fuel, and are dependent that the fuel supply can be maintained even during power outages.
- *Dependency of water supply:* As a worst-case scenario the hospital cannot receive any patients if they cannot provide a clean environment. Further, the ambulance service are to some extent dependent on water supply for cleaning. If a power outage affects the water supply, it might affect the ambulances ability to operate safely. Especially the hospital has a very high usage of water.

5 Overall assessment of findings from the Norwegian project

In this chapter the aim is to outline and summarize some overarching and central findings from the Norwegian project as a whole. The chapter also aims to place and interpret findings from the project in a wider context.

The first part presents findings related to the chosen analytical model and work process. The second part of the chapter continues with lessons learned in terms of identified vulnerabilities and measures to reduce risk related to power outages in cities.

5.1 Analytical model and work process – coordination role and sectoral responsibilities

As mentioned in chapter three, Norwegian municipalities are required to conduct a holistic multi-hazard risk and vulnerability assessment, and they must involve other relevant regional and local civil protection stakeholders in the process.

In guidance material for the municipalities it is stated that an assessment is often made by using scenarios with triggering events, such as flooding, storm, accident etc. Such hazards are likely to affect several other vital societal functions. The municipalities *may* then continue by developing a new scenario based on identified failures caused by the triggering event. This scenario can be assessed using the same method as with the triggering event. [46]

The analytical model chosen in MEREPUV is similar to the latter form of assessment. Risk of disruption in a vital societal function is assessed in relation to one specific cause, namely power outage. The chosen model focuses on interdependencies and cascading effects, and emphasizes consequences more than probability.

One model, three different city reports
The project in DSB developed a relatively detailed template where the analytical model was broken down to specific questions to be answered in all three city assessments. Still, the project notices that the Norwegian city reports have turned out to become rather different end products. There are several reasons for this. The three cities represent three different organisations in terms of experience, culture and expertise, which affects how the task has been solved. The project has also to some degree been open for local adaptation of the template.

The strict adherence to frameworks versus local adaptation is a difficult balance that needs attention in work with guidance material for municipalities.

Topics not assessed using the chosen model
The Norwegian cities have pointed to some limitations with the analytical model, which have caused some challenges during the cities' work. For instance, the model does not contain an assessment of direct impact of power outage on life and health and social stability. This can be a somewhat strange limitation since the citizens are expected to be heavily affected directly by the power outage, but also indirectly due to disruptions in several other vital societal functions. As such, the model invites the cities to focus on a more limited part of the overall impact on life and health due to power

[46] DSB 2019b): s 27

outage. It focuses exclusively on effects of power outage on life and health and social stability caused by disruption in the rescue, health and electronical communication services.

Some partners have also experienced the analytical model to be rather rudimental in the sense that it represents a simplification of the real complexity in topics being addressed. Complex orders and cause-effect relations, as well as a precise estimation of impacts, are examples of topics mentioned as difficult during the process. At the same time, all the three Norwegian cities agree that the model, to a large degree, opens for a rudimental overview about cross-sectorial dependencies, and cross-sectorial blind spots.

Apparently simple model, still complex and time consuming
All three Norwegian cities have reported that even though the model and guide made for the assessments are quite rudimentary, the process of producing an assessment has nevertheless required a considerable amount of time and resources.

All the cities have found it necessary to limit the scope of the original model to some degree. For example, the cities have seen the need to exclude some relevant critical input factors or cascading effects from the assessment in order to achieve a manageable scope. Furthermore, some adaptations of the questions addressed in the joint guide for the assessments, have also been made.

To get an overview of a vast topic such as societal consequences of power outage, requires data gathering and expert knowledge from very many different fields. In addition, it might be difficult to find available information on some topics due to limited empirical data, and it can be difficult to sort out the most relevant information in the data gathered. The challenge in developing applicable tools and models to deal with the complexity at the appropriate level of detail is an important lesson learned in the project.

In risk assessments conducted by DSB, an assessment of a chosen scenario's impact on vital societal functions, is carried out as an integral part of all such scenario assessments. [47] This is also an ambition evident in regulations and guidance material for municipal holistic risk assessments.[48] Findings from DSB`s annual survey towards municipalities seem to show a positive trend in the number of municipalities assessing their ability to maintain vital functions during adverse events.[49] The experiences from the project however, is that the cities do not seem to be as used to assessments of vulnerability and impact on vital societal functions as anticipated.

The project recommends that a further examination is undertaken of how vulnerability assessments and impact on vital societal functions are integrated in the work with municipal holistic risk and vulnerability assessments. The involvement of municipal sectors and other stakeholders in such work, should also be studied closer.

The project suggest that the experience from MEREPUV is taken into account in revisions of existing guidance material for municipalities on such vulnerability assessments. Finally, the experience from the project shows that it is important to maintain focus on the municipalities` work with risk and vulnerability assessments as such, in terms of resources, methodology, stakeholder knowledge etc.

[47] See for instance DSB 2016a)
[48] Regulation on municipal preparedness duty, DSB 2019b): s 27, 30
[49] DSB 2019c): s 13,14

Coordination role and principle of responsibility

As mentioned in chapter 3, Norwegian municipalities face several regulations that apply for the municipalities' work with civil protection and safety and security. The coordination responsibility following from the regulation on municipal preparedness duty, does not in any way, replace or change obligations given to the municipalities in other sectors laws. [50]

The Norwegian partners from the cities have represented the municipality`s coordination role. They have conducted the vulnerability assessments, involved stakeholders and led local expert seminars etc. The partners from the municipalities do not possess detailed expert knowledge from other municipal sectors' area of responsibility. Rather, they have knowledge about important civil protection stakeholders, risk factors in the municipality, vital societal functions and experience with holistic risk and vulnerability assessments. The vital functions chosen by the cities;- health, rescue and electronical communication services, consist of capabilities both internal and external to the municipal responsibility. Thus, the involvement of other municipal sectors, with duties related to prevention and preparedness within their respective areas, together with relevant national and private stakeholders, has been a crucial success factor. The intention of the locally arranged expert seminars has been to ensure such involvement.

The relation between coordinating and sectoral responsibilities will often be a question of balance and clear understanding and knowledge of roles. A key concern in the project has been whether involved stakeholders would consider that the municipal "coordination agents" went too far into areas of responsibility owned by others. The cities' impression however, has been the opposite, and they report that involved stakeholders have appreciated the initiative.

The reliance on knowledge from involved stakeholders represents both a potential and a challenge in producing assessments. The potential is related to many stakeholders gathering and contributing to illuminate a topic from different perspectives and different areas of expertise. Many of the stakeholders involved in the local expert seminars do not necessarily meet often. This can open up for effective learning for all participants in terms of dependencies, blind spots, unclear sectoral boundaries etc. These are issues typically associated with core activities in coordination initiatives. The cities' impression is that the local expert seminars have contributed to such an effect, with raised awareness, understanding and realization of vulnerabilities and dependencies among all stakeholders involved in the process.

There is also reason to believe that the quality of coordination initiatives are strengthened when municipal coordinators have a good understanding of roles and responsibilities of other (municipal) stakeholders. The Norwegian cities report that they have learned a lot about this during the process, and that it has been useful for them.

A challenge with the high degree of reliance on external stakeholders' knowledge is, amongst others, that it can be difficult for non-experts to get a sufficiently precise understanding of complex chains of consequences and important technical aspects. The identification of effective measures requires that the right experts are brought to the table, that they want to share, and that the recipient understands the information correctly. It can be assumed that the process becomes more challenging when the involvement of external stakeholders, such as private and national

[50] DSB 2019a): s 12, 15

stakeholders, is high. These are important aspects that municipal coordination agents must be aware of, and it can affect the degree of uncertainty in the assessments.

At the same time, it is important to underline that the purpose of the assessments in this project has not been to replace sector specific risk and vulnerability assessments. Rather, the objective has been to contribute to improved understanding among a broad set of stakeholders of cascading effects related to power outage and how various stakeholders are dependent on each other`s prevention and preparedness efforts in such a case.

An interesting following up question from the project could be to examine whether vulnerability assessments are common within municipal sectors such as fire and rescue, water and sewage etc., and what methods such assessments builds on. This is also connected to the suggestions described in chapter 5.3.2 below.

The lesson learned from MEREPUV is that it appears that the project seems to have balanced well between coordination and sectoral responsibilities, and that learning in terms of roles and responsibilities has been an important effect of the project. Both DSB and the cities think that the project objectives related to improved knowledge and raised awareness have been achieved to a large extent

5.2 Findings and proposed measures based on the three city assessments

5.2.1 Identification of proposed measures by the cities

As described in chapter two, there are many already existing barriers established to avoid severe power outages to occur, and to reduce consequences if it occurs.

At an overarching level, all three cities have also evaluated the need for risk reducing measures, and recommended implementation of new measures. Most of the proposals are of a character that enables implementation on basis of municipal decision-making, or in collaboration with other local civil protection stakeholders located in the municipality. The proposals vary in scope as exemplified below.

An example of a relatively modest measure proposal is Stavanger's suggestion to point out and communicate to citizens where they can go to get information in case of a long lasting disruption in electronical communication services. Another example is their proposal to initiate cooperation between relevant local stakeholders, in order to develop routines and procedures to ensure early warning to the relevant stakeholders in a situation with power outage. Such early warning mechanisms can ensure that important preparedness efforts are taken while electronical communication services and communication devices are still operational and not affected by the power outage.

One example of a proposed measure that is slightly more extensive, yet fully possible to implement by municipal decision-making, is Bergen's proposal to go through the municipality's IT infrastructure with the aim to identify and strengthen critical elements at various levels.

Finally, there are also examples of proposals which would require further assessment and decision-making at the central level. One example is Oslo, who addresses a question of whether more joint

guidelines for preparedness against power outage should be considered for the police, fire and rescue and ambulance services.

The cities identification of measure proposals illustrates that even if the topics addressed are complex and extensive, it is still possible to improve risk management by rather simple measures that are available locally, and not only by comprehensive and expensive measures managed at the central level.

5.2.2 Need for more knowledge about self-preparedness within vital societal functions?

From the three Norwegian risk assessments we see that power outage affects almost all vital societal functions, for instance supply of water and fuel, road transport, rescue services, health services, electronical communication services, crisis management and crisis communication.

This confirms and supports previous studies.[51] Power supply is a crucial input factor for society. Thus, it also deserves high and continuous attention in the work with civil protection both in terms of high degree of redundancy in infrastructures, but also in terms of focus on self-preparedness amongst other services dependent on electrical power in order to operate. The latter might be especially important in cities where the probability of power outages is estimated to be very low due to robust infrastructure. One may ask if this can lead to less focus on self-preparedness for power outage in cities. Even if the probability is low, all the three Norwegian assessments conclude that the consequences of a long duration power outage would be severe for other vital societal functions and ultimately life and health in the cities.

A newly finalized project about electrical safety has pointed that there is a need to look closer at the requirements related to emergency power systems in DSB's regulations, as the requirements are seen to be vaguely formulated. The project has also proposed that DSB should initiate an examination of how back-up solutions for electrical power are regulated in other laws and regulations. In addition, the project recommends that DSB conducts an assessment of how other vital services and functions can be assisted in terms of information and guidance about emergency power[52]. The MEREPUV project supports these proposals from the electrical safety project.

However, the findings from the Norwegian cities also indicate that failure in electronical communication services may be just as severe as a power outage in itself, and that such a failure also would affect almost all other vital societal functions in addition to life and health. Furthermore, electronical communication services have a very high dependency on operational power supply. This is also a conclusion found in several previous assessments.[53] DSB, NVE and NKOM have many times underlined the importance of sufficient self-preparedness in vital services against disruptions in power supply and electronical communication services.[54]

The MEREPUV project therefore suggests to undertake a systemic review of regulations and requirements of self-preparedness in various enterprises and services. Such a review could start by focusing on municipal and private "owners" of vital societal functions and capabilities. Electrical power and electronical communication could be highlighted in such a project, as the electrical safety

[51] DSB 2012, NVE 2014:49: s 14,15, 23
[52] DSB 2017a): s 80-82
[53] DSB 2014, DSB 2013
[54] NVE 2012:03: s 14-16, 2012, Post- og teletilsynet 2012: s 9, Presentasjon NVE 28.aug 2018 MEREPUV seminar

project suggests, but the review should also include self-preparedness in general. An important objective could be to examine to what degree vital services have established a risk management system. Central questions in such a review could for instance be:

- Are there any requirements for assessing vulnerability to various strains / adverse events in terms of ensuring continuity of the service? Does this comprise assessing dependencies on external critical input factors?
- To what degree are vital services and enterprises aware of their criticality for other vital functions?
- Are there any requirements of self-preparedness?
- Are there requirements of preparedness efforts to avoid cascading effects in the case of disruptions?
- If such requirements exist, does guidance material explain how to comply with the requirements, or are standards on risk management used?
- Are there any control mechanisms for assessing degree of compliance?

The data gathered by the Norwegian MEREPUV project also supports the electrical safety project`s conclusion that there are differences between sectors when it comes to if and how self-preparedness against power outage is regulated. Some services have specific requirements for back-up capacity in case of power outage, for instance demanding capacity for a defined amount of time.[55] Other areas have a more purpose-based regulation.

Purpose-based regulation is characterized by more general requirements and they are often directed towards goals and results, and not towards specific methods for how to achieve the goals or results. Purpose-based regulations are also often associated with terms like "sufficiently safe", "sufficient degree of safety" etc.[56] The regulations are not always accompanied by more detailed guidance of how the result or goal can be achieved when applied on a specific topic such as for instance self-preparedness against outage in power supply or electronical communication services.

There are advantages and disadvantages with both prescriptive regulation and purpose-based regulation. The preferred form is ideally balanced and defined on basis of several factors. Ability, resources and capacity for compliance are examples of such factors that are assumed to affect the effectiveness of various regulation forms. For instance, the effectiveness of general requirements as basis for defining an acceptable level of self-preparedness, is expected to be low, if ability in terms of knowledge, resources and capacity for compliance is low.[57]

The Norwegian MEREPUV project finds that the question of regulation form seems relevant both when discussing self-preparedness against specific hazards, such as outage of power supply or electronical communication services, and when looking at self-preparedness in general. Yet, the project cannot draw any clear conclusions based on our findings. Similar questions were also raised after the hurricane Dagmar, where the Norwegian Communication Authority pointed at a need for improved guidance material about preparedness related to electronical communication services for the municipalities.[58]

[55] Presentasjon Mattilsynet 28.august 2018
[56] (Red) Hempel, Kringen, Braut s 16-17, 37,38
[57] (Red) Hempel, Kringen, Braut s 50 - 66
[58] Post og teletilsynet nr 2 2012: s 16

It would be interesting for another project to examine more closely whether regulation appears to be an effective tool for ensuring sufficient self-preparedness in vital capabilities and functions, and if so, what regulation form that seems to be the most effective. Such a project could be carried out as a research project.

5.2.3 Information campaign about self-preparedness within vital functions?

DSB has recently implemented an information campaign about self-preparedness among Norwegian citizens. In short, the campaign recommends all Norwegian households to have a storage with food, water, necessary medical supplies and other assets, which can enable them to be self-sufficient for 72 hours, in case of failures in vital functions or other adverse events.

The Norwegian MEREPUV project suggests a similar campaign is considered carried out towards services defined as vital in the Norwegian "Vital societal functions"-report. The main question could be related to how well prepared owners of vital societal functions and capabilities are when it comes to operating their services under various kinds of strains.

5.2.4 About the role of The Local Electrical Supervision Authority (DLE)

Every year, the Norwegian DLE carries out a high number of inspections and audits towards owners of low voltage installations. DSB develops a checklist with mandatory check points for DLE to verify during audits and inspections. The project suggests to consider including electrical safety service systems / emergency power systems on the list of mandatory checkpoints for audits and inspections of objects where power outage could represent a risk for citizens directly or indirectly. Such an initiative would also provide a better overview than today of the status in preparedness efforts against power outage in vital services and functions.

The project also suggests that DSB considers whether the framework "Vital functions in society" could be useful for developing activities related to the DLE audits. Such thinking seems to correspond well with measures given by the earlier mentioned project for Electrical safety in DSB. They suggest to instruct the DLE to get a better overview of vital functions within their area of responsibility, and that DLE should work actively to improve preparedness against power outage in such services and functions.[59] With reference to chapter two in this report, such a direction for DLE, should probably be discussed closely with other authorities which audit capabilities / vital societal functions, to sort out who audits what.

5.2.5 Electronical communication - by many considered as a difficult topic

From the Norwegian project, there are indications that many stakeholders consider electronical communication to be a complicated and technical topic that best can be dealt with by experts. This might suggest that many stakeholders who are primarily end-users with high dependency of ecom-services, experience thresholds when it comes to assessing their own vulnerability to ecom disruptions.

Digital safety and security is currently highlighted as one of the prioritized areas in DSB, and the findings in MEREPUV seem to support findings from a recent survey[60] with a similar focus done by DSB towards municipalities. The experience from the Norwegian cities` assessments should be taken into account in initiatives at this area towards regional and local level. It could also be useful to get

[59] DSB 2017a): s 86
[60] DSB 2018b)

an overview of whether scenarios of disruptions in electronical communication are common in municipal holistic risk and vulnerability assessments, and also in municipal sector-specific risk and vulnerability assessments.

5.2.6 Robust electronical communication infrastructure in cities

In Norway, a program for strengthening electronical communication infrastructure in certain areas of the country is currently ongoing. The prioritization of municipalities and locations for such strengthening of electronical communication, is done in cooperation between NKOM and DSB[61]. Project MEREPUV would like to point out the importance of continuous focus also on ensuring redundancy in bigger cities, since disruption in electronical communication services in big cities quickly can lead to severe consequences for a lot of people and vital societal functions.

5.2.7 Fuel – a critical input factor for back-up power solutions

All the Norwegian assessments point to fuel supply as a critical input factor to operate back-up power solutions in case of power outage of long duration. Findings from the project also indicate that there might be a need for more information to relevant local and regional stakeholders of existing plans for distribution of fuel, in a situation with shortage due to power outage. The project recommends that DSB assess how this best can be followed up.

5.2.8 Communication with citizens, other collaborators and internal communication.

All the Norwegian assessments find that a serious consequence of power outage is related to disruptions and fall-out of emergency calls from citizens to the call centers of the rescue services. This could lead to loss of lives that under normal circumstances would have been saved. The Norwegian cities also mention that failures in other communicative devices, such as safety alarms used by elderly and vulnerable people to get in touch with health care, can lead to casualties.

Furthermore, challenges related to the spread of information to the public in general, is expected to be very difficult in the chosen scenarios. The same is the case for internal communication between different municipal stakeholders, but also between the municipality and other important stakeholders central for dealing with a situation with power outage.

The municipalities are required to develop plans for crisis communication towards their citizens and other stakeholders. The project concludes that it is crucial that such plans also include how to manage the need for information and communication in a situation where ordinary communication devices are unavailable due to disruptions. Such plans must be agreed upon by various stakeholders and trained regularly. An important lesson learned from the project is also the importance of having thought about communication channels such as radio, and about what advice to give citizens in a situation with power outage or outage in electronical communication services, including special plans for how to reach vulnerable groups.

5.2.9 The importance of a common framework defining vital functions in society.

In Norway, the Ministry of Justice and Public Security has the responsibility for coordination of civil protection work at the central level. This is similar to the responsibility for coordination that municipalities and county governors have at local and regional level. DSB supports the Ministry in their coordination role. Among the responsibilities following from the coordination role at central

[61] NKOM 2017: s 12

level, is to provide an overview of vital functions in society from a civil protection and cross-sectoral perspective. The purpose of the public report "Vital Societal Function" is to give such an overview. One of the objectives for the report is to contribute to a more systemized and targeted civil protection work across sectors as well as within the different sectors. The report is also meant to be used as basis for defining further civil protection activities, such as work with self-preparedness, management, prioritization of audit activities, stakeholder management etc.[62] The framework is adapted to a local context in guidance material for municipalities[63].

The Norwegian MEREPUV project considers the framework to be of great importance for creating a higher degree of mutual understanding of what is to be understood as vital societal functions in a civil protection perspective. The report also contributes to give civil protection work a more concrete content, and is an important tool for assessing interdependencies and cascading effects across vital functions. Furthermore, the report gives a clear indication of which stakeholders that should be involved in civil protection coordination efforts both at local, regional and central level.

[62] DSB 2016 b)
[63] DSB 2019 b)

5.3 Summary of main findings from the Norwegian MEREPUV project

Main findings
Analytical model and work process • The organizing of the work process seems to have contributed well to a rudimental overview about vulnerabilities, cross-sectorial dependencies and roles and responsibilities related to power outage. However, the uncertainty of the cities assessments is still evaluated to be high, partly due to the degree of complexity in the topics being addressed but also because of lack of available empirical data. • Experience from the project indicates that there may be a need for more guidance about how the municipalities can assess vulnerability in vital societal functions at an overarching level, as part of their holistic risk and vulnerability assessments.
Other findings • Even though the probability for long lasting power outages is low, all the three city assessments conclude that the consequences of such a scenario would be severe for other vital societal functions and life and health. • The degree of self-preparedness among Norwegian households has been an important topic in DSB recently. The project suggests that a similar focus is considered towards owners of vital capabilities and / or functions. A following up project is also suggested for examining how self-preparedness is managed within municipal and private owners of vital capabilities and / or functions. Furthermore, the project suggest that more research is carried out, to examine whether regulation or other public tools seem to be the most effective tools for contributing to self-preparedness in vital services. • The project supports the findings from the recent El-safety project and suggests that DLE considers to collaborate closely with other auditing authorities when evaluating if DLE to a larger degree should carry out audits with emergency power systems / electrical safety services in vital capabilities and functions. • Findings from the project indicate that electronical communication is considered to be a technical and difficult topic by many stakeholders involved in the project. • Stable access to fuel and challenges related to communication are described in all three city assessments as elements that stand out as very important in a scenario with power outage. • A joint national framework defining what is to be meant with vital functions and critical infrastructure from a civil protection perspective, has been very important in the Norwegian project. This has been used to define the analytical objects, to assess critical input factors and cascading effects, and to identify which stakeholders to be involved in the process.

6 Dissemination of results

The results of MEREPUV will be disseminated in various ways; it has been an ambition of the project to develop knowledge and methodology which can be utilized at local, national and regional level and in other European countries. The project may have an impact on planning and decision-making in multiple sectors. The output of the cities' assessments highlight not only the need for cross-sector coordination, but also the need to look at impacts of power outage at regional (county) or even national level. Although the probability of such events is extremely low, the results of MEREPUV can provide knowledge and learning points which can enhance prevention and preparedness measures at all levels and in various sectors. Dissemination of the results is thus critical in the years to come.

Local level
The cities' reports have already been utilized in all participating cities and constitute vital inputs for further planning, including holistic risk and vulnerability assessments, and disaster preparedness at municipal level. Due to the municipalities' mandate to coordinate civil protection and emergency planning according to the Norwegian Civil Protection Act, the municipalities will be in the frontline when it comes to define and implement preventive measures within their own areas of responsibility; to enhance prevention and preparedness for power outages in the private sector; and to further develop municipal contingency plans in case of undesired events.

Each city participating in MEREPUV will ensure that the results of their own report becomes well known by the municipal administration and its political leadership, and that the reports will be used as basis for further planning at local level. Dissemination at local level can be done in numerous ways; in local seminars and workshops, in municipal planning processes, through local media, etc.

Further, as coordinating institutions for civil protection and emergency planning, the cities will make use of already existing networks, such as municipal emergency councils, to ensure that relevant stakeholders will make use of the city reports.

Regional (county) level
All cities have benefitted from including regional stakeholders in their assessment process, such as the county governors, regional suppliers of electric power, regional health authorities, or other regional institutions. At regional level, the county governor is responsible for coordination of civil protection and emergency planning – similar to the municipalities' role at local level. The county governors have established regional emergency councils which may use the results of MEREPUV in their work. Both the cities and the Norwegian Directorate for Civil Protection (DSB) will be able to share results from MEREPUV to relevant county governors, and thus to the regional emergency councils throughout Norway. DSB will also ensure that other county governors will get information about results, findings and new methodologies developed in MEREPUV.

National level
The national working paper will be published online, including links to, or information about, the cities' reports. This will simplify the dissemination to all stakeholders in civil protection and emergency planning, including national authorities, regional authorities, municipalities, the private sector, universities/research institutions, and NGOs.

The final conference (November 2019) will be open for all relevant stakeholders from the participating countries as well as other European countries and institutions, and will constitute the first major event to present the outcomes of the project. Further, information about MEREPUV may be presented in the annual national conference on societal safety, in February 2020, or at similar national events.

DSB has an overall coordinating role for civil protection and emergency planning at national level, on behalf of the Ministry of Justice and Public Security. DSB develops guidelines for ministries to enhance civil protection and emergency planning at national level within all relevant sectors. DSB carries out audits of the ministries and their underlying agencies to assess how they fulfil their tasks. The results of MEREPUV will make the basis for recommendations for further actions at various ministries and agencies. Thus, DSB can present the outcome of MEREPUV in their work targeted towards ministries and other agencies, and include recommendations from MEREPUV when following up relevant agencies.

International level

DSB, as well as the participating cities, participate in a wide range of international arenas, including conferences, workshops, programmes and international projects. All partners will seek to disseminate the outcomes of MEREPUV where relevant, making use of already existing arenas – especially after the project has been finalized and it is possible to present results from all three participating countries, and all five cities.

Further, there is a potential for follow-up by developing new projects, based on the same concept and methodology developed in MEREPUV. There is a potential for exploring interdependencies between other societal functions than those covered in this project, or for going more into details in some of the analysed sectors. The proposed Care4Power project, coordinated by Safety Region South, is a direct follow-up of MEREPUV.

7 List of literature and other sources used in the report

DNK 2014: *Robusthet i transmisjon – reservstrøm i transmisjonslinjer i Nødnett*. Rapport

DSB 2019a) Guide to the regulation on municipal preparedness duty

DSB 2019b) Guidance to holistic risk and vulnerability assessment in the municipality

DSB 2019c): *Kommuneundersøkelsen 2019*. Rapport

DSB 2019d): Instruks for det lokale elektrisitetstilsyn

DSB 2018a): *Kommuneundersøkelsen 2018*. Rapport

DSB 2018b): *IKT sikkerhet på lokalt og regionalt nivå.* Intern rapport

DSB 2018c): Instruks for det lokale elektrisitetstilsyn

DSB 2017a): *Elsikkerhetsprosjektet. Sluttrapport – helhetlig gjennomgang av DSBs arbeid med elsikkerhet*

DSB 2017b): *Vital functions in society. What functional capabilities must society maintain at all times?* Rapport

DSB 2016a): *Risikoanalyse av regnflom i by. Krisescenarioer 2016 –analyser av alvorlige hendelser som kan ramme Norge.* Rapport

DSB 2016b): *Samfunnets kritiske funksjoner. Hvilken funksjonsevne må samfunnet opprettholde til enhver tid. Versjon 1.0.*

DSB/NEK Elsikkerhetsprosjektet 1/2016: *Vår elektriske fremtid. Et veikart for elsikkerhet – utfordringsbildet.* Rapport

DSB 2014: *Risikoanalyse av "Cyberangrep mot ekom-infrastruktur"*. Delrapport til Nasjonalt risikobilde 2014

DSB 2013a: *Evaluering av øvelse Orkan 2012.* Rapport

DSB 2013b: *Nasjonalt risikobilde*. Rapport

DSB 2012: *Nasjonalt risikobilde.* Rapport

DSB 2008: *Brann i kabelkulvert Oslo Sentralstasjon 27.11.2007*. Rapport

Meld. St. 25 (2015-2016) *Kraft til endring*

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NKOM 2017: Årsrapport

Norconsult 2014-02-14: *Langvarig strømbrudd i Lofoten. Sårbarhets- og konsekvensvurdering.* Oppdragsnr.:5133772

NVE 60/2018: *Driften av kraftsystemet 2017*. Rapport

NVE Fakta nr 3/08/2018: *The Norwegian power system. Grid connection and licensing*

NVE 49/2014: *Øvelse Østlandet 2013*. Evalueringsrapport

NVE 03/2012: *Førsteinntrykk etter Dagmar julen 2011*. Rapport

NVE 45/2012: *Trær til besvær. Lærdommer om skogrydding i etterkant av ekstremværet Dagmar*. Rapport

Olje og energidepartementet 2015: Fakta Energi- og vannressurser i Norge

Ot.Prp. nr. 62 (2008-2009) *Om lov om endringer i energiloven*

Post og teletilsynet 6. juni 2014: *Minstekrav til reservestrømkapasitet i landmobile nett.* PT-ref. 1402794 (https://www.nkom.no/teknisk/sikkerhet-og-beredskap/ekomsikkerhet/tilbyders-sikkerhets-og-beredskapsplikter/_attachment/13634?_ts=152ca99b531)

Post og teletilsynet rapport nr 2 2012: Foreløpige erfaringer og forslag til tiltak etter ekstremværet Dagmar

Post- og teletilsynet 2012: Høringsbrev – forslag til justerte tiltak etter Dagmar

Statnett 2014: *Energiskolen* Lærerhefte

(Red) Hempel, Kringen, Braut 2018: Regulering og standardisering. Perspektiver og praksis. Universitetsforlaget

Presentasjoner MEREPUV fagseminar 28. august 2018

- Presentasjon fra NVE
- Presentasjon fra NKOM
- Presentasjon fra Mattilsynet
- Presentasjon fra Helsedirektoratet
- Presentasjon fra Statens Vegvesen
- Presentasjon fra Politiet
- Presentasjon fra DSB-ELS
- Presentasjon fra DSB-BRE
- Presentrasjon fra DSB-NBK
- Presentasjon fra DSB-PROD

Nettsider:

https://energifaktanorge.no

- https://energifaktanorge.no/norskenergiforsyning/forsyningssikkerhet
- https://energifaktanorge.no/norskenergiforsyning/kraftforsyningen

https://www.tu.no/artikler/politiet-2006-strombrudd-lite-sannsynlig/323707

http://www.hioa.no/extension/hioa/design/hioa/images/sifo/files/file79978_presentation_dagmar_homerisk_kick-off.pdf

Annexes

Annex 1 Joint methodology in MEREPUV

Analytical model

The assessment conducted is done within the framework of the so-called bow tie model. The model is adapted and specified on basis of purpose, analytical object and main questions to be examined in the assessments. The following risk elements are assessed:

- Probability
- Vulnerability
- Consequences
- Uncertainty

In addition, one other element is assessed:

- Steering ability: How manageable are the risk and vulnerability attached to the scenario? To what degree are there available measures which are likely to reduce risk and vulnerability?

Vulnerability in health services / rescue services / EKOM services is the analytical object in the model.

Choice of scenarios

Describe the choice of scenarios of power outage

Assessment of probability – how likely is it that the scenario will occur?
The probability assessment builds on results and insights from earlier risk and vulnerability assessments and other available existing knowledge and data material.

The probability intervals used are:

- Very low probability: 0-10 per cent likely in 50 years
- Low probability: 10-40 per cent likely in 50 years
- Moderate probablity: 40-60 per cent likely in 50 years
- High probability: 60-90 per cent likely in 50 years
- Very high probability: 90-100 per cent likely in 50 years

How do the scenarios affect other vital functions?
In the assessments we are examining whether and how the scenarios affect other critical input factors of which health services are dependent on in order to function.

How are health services affected?

In the assessment we are describing how the different scenarios affect health services, either directly or indirectly, due to failure or disruption in one or several other critical input factors for health services.

Furthermore, an overall assessment is made of how health services are affected in total. The assessment is based on a five-part scale from very low to very high degree.

Cascading effects and consequences for other vital societal functions
By examining other vital societal functions` dependency on health services, we get an impression of vulnerability in society related to failure in health services.

Societal impact
In this assessment we have chosen to assess consequences for society and citizens by focusing on the following societal values / types of impact:

- Human impact / life and health
- Societal stability / social impacts

The impact type "life and health" is further divided into two consequence categories: 1) number of deaths expected deaths and 2) number of severly injured or ill people

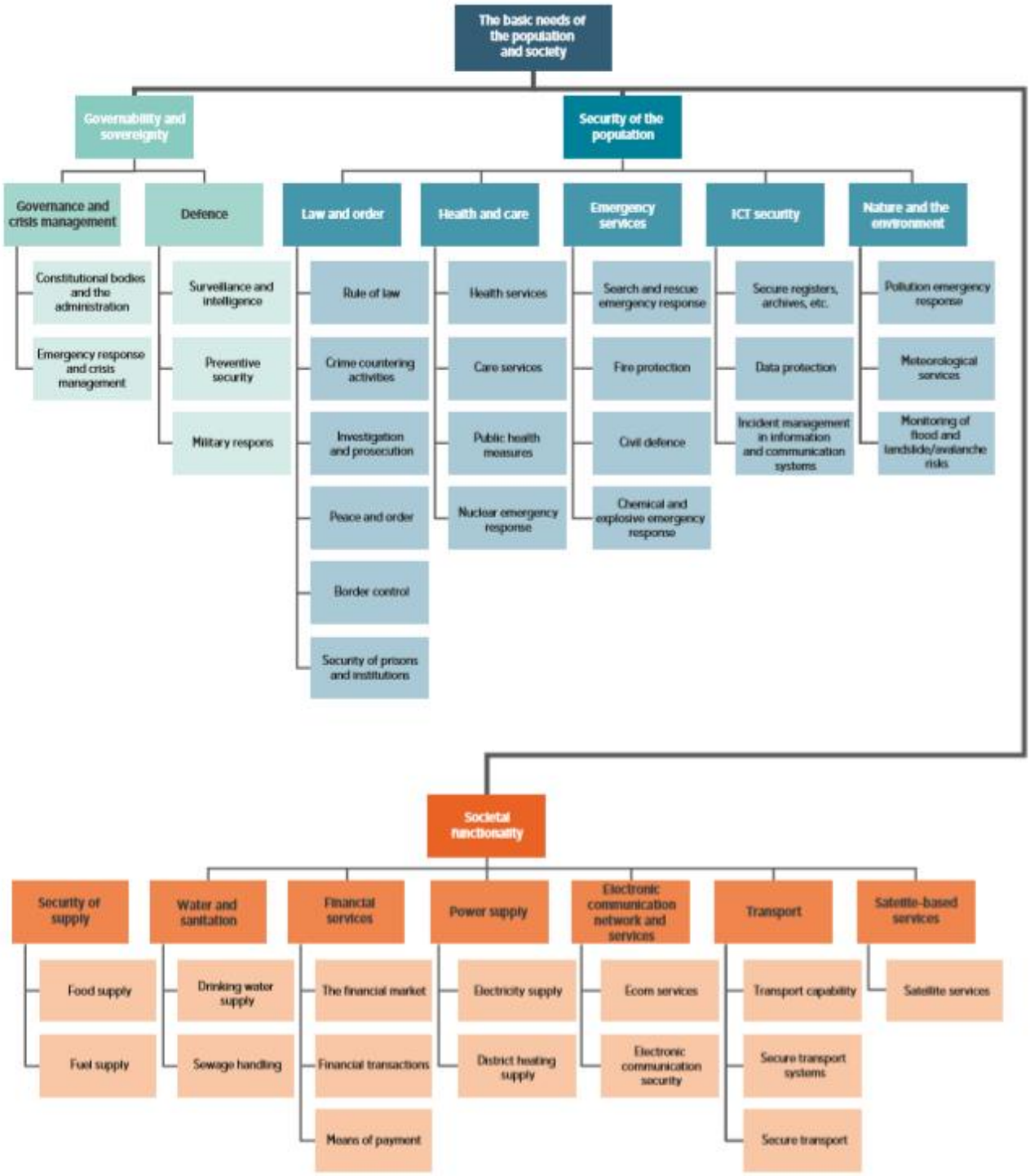
The impact type "societal stability" is further divided into two consequence categories: 1) Social and psychological reactions and 2) Challenges in daily life

Uncertainty and steering ability
Assessment of degree of *uncertainty* is related to an evaluation of the quality of excisting knowledge used in the vulnerability assessment as well as an evaluation of to what degree the results are sensitive to changes in the conditions.

Degree of *steering ability* is evaluated by an assessment of whether efficient measures, of which can reduce the risk and vulnerability, exist and are well known. This is an important evaluation after the results of the risk and vulnerability assessment are ready and alternatives of measures are being adressed.

Annex 2 Vital societal functions and capabilities in Norway

Screenshot the 14 vital societal functions and belonging capabilities in the Norwegian report "Vital functions in society"



Annex 3 list of involved directorates and agencies:

Aktør	Hva
NVE	Continous dialogue during the project period and main source / provider of expert assessment chap 2 Contribution in seminar 28. august 18 Contribution in local expert seminars Consulted before finalizing English city summaries Consulted before finalizing Norwegian working paper
Helsedirektoratet	Contribution in seminar 28. august 18 Consulted before finalizing English city summaries Consulted before finalizing Norwegian working paper
Statens Vegvesen	Contribution in seminar 28. august 18 Consulted before finalizing English city summaries Consulted before finalizing Norwegian working paper
Politidirektoratet	Consulted before finalizing English city summaries Consulted before finalizing Norwegian working paper
Nasjonal kommunikasjonsmyndighet	Contribution in seminar 28. august 18 Contribution in local expert seminars Consulted before finalizing English city summaries Consulted before finalizing Norwegian working paper
Mattilsynet	Contribution in seminar 28. august 18 Consulted before finalizing English city summaries Consulted before finalizing Norwegian working paper

Contribution from other departments in DSB	
Department for prevention and safety - section for for electrical safety - section for fire and rescue - section for product safety DSB-depatment for public safety communications	Continous dialogue during the project period Contribution in seminar 28. august 18 Consulted before finalizing English city summaries Consulted before finalizing Norwegian working paper