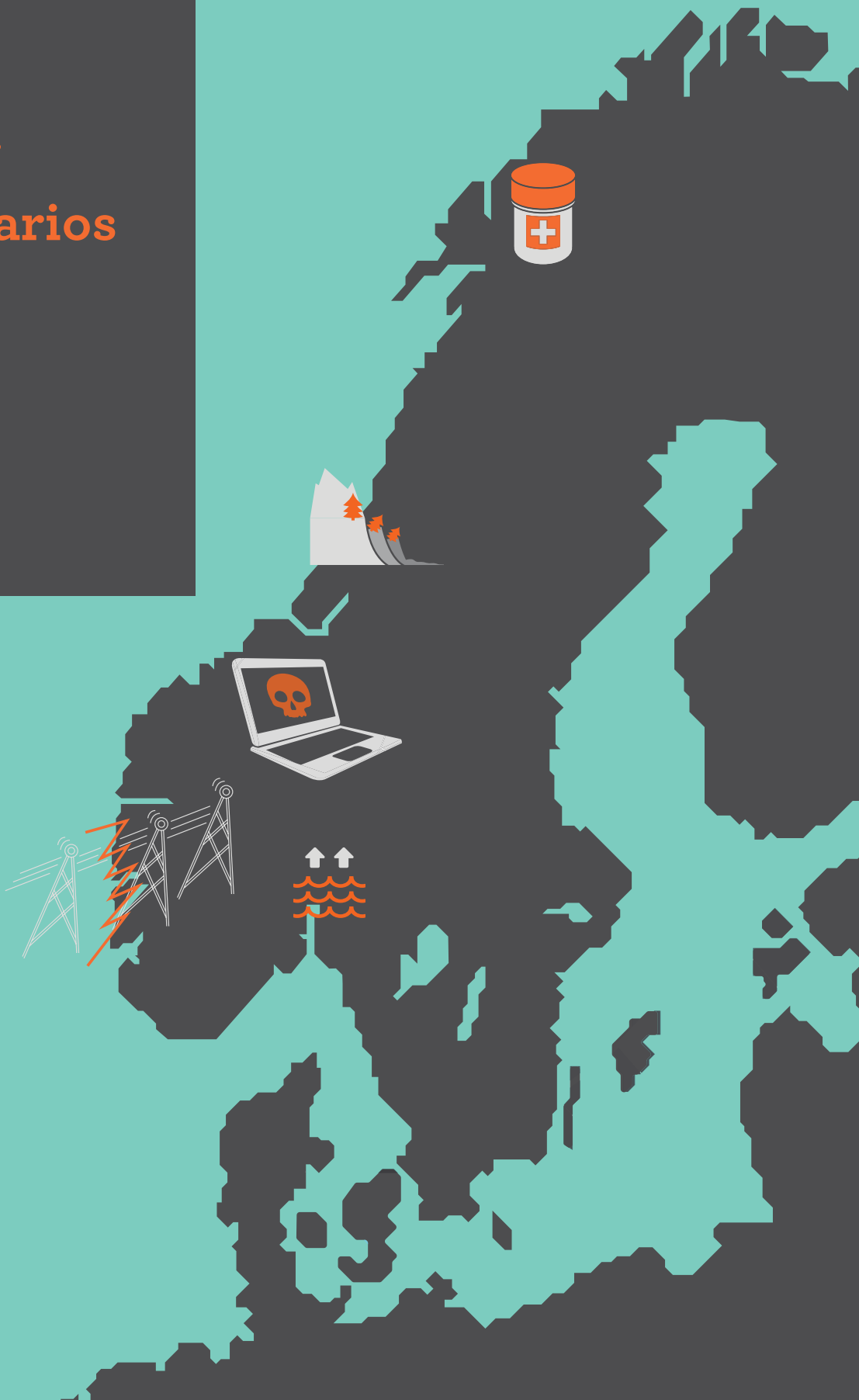
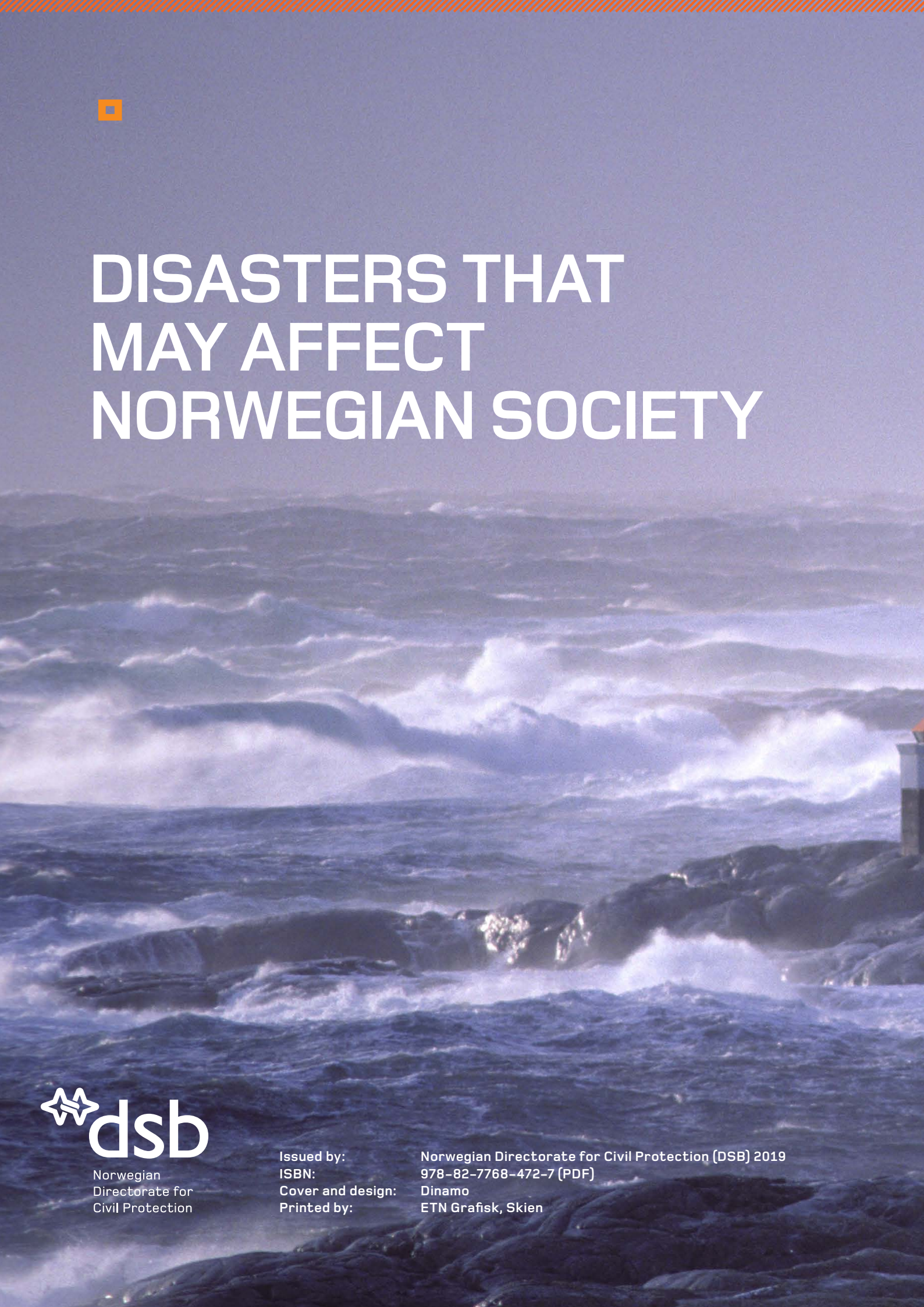
dsb Norwegian Directorate for Civil Protection

Analyses of Crisis Scenarios

2019



DISASTERS THAT MAY AFFECT NORWEGIAN SOCIETY



dsb
Norwegian
Directorate for
Civil Protection

Issued by: Norwegian Directorate for Civil Protection (DSB) 2019
ISBN: 978-82-7768-472-7 (PDF)
Cover and design: Dinamo
Printed by: ETN Grafisk, Skien

SEVERE WEATHER
Hurricane on the coast. Frøya municipality, Trøndelag.

PHOTO TORE WUTTUDAL / SAMPHOTO

The DSB's Analyses of Crisis Scenarios (ACS)[1] is one of four threat and risk assessments published every year. The others are published by the Norwegian Police Security Service (PST), the Norwegian Intelligence Service (NIS) and the Norwegian National Security Authority (NSM).

The PST's primary responsibility is to prevent and investigate crimes against national security. The PST's annual threat assessment discusses situations, usually in Norway, that could affect Norwegian security and damage national interests in the coming year. These include threats from state actors in the form of foreign intelligence services, their current intelligence targets and the services' operational patterns in Norway. The assessments also deal with threats from non-state actors, especially threats of politically motivated violence by extremist groups or individuals. The assessments have a time horizon of one year and are published in the first quarter.

The NIS's primary task is to warn of external threats and support the development of Norwegian security, foreign and defence policy. The service publishes an annual assessment of the international situation and foreign threats of significance to Norway and Norwegian interests. This year's 'Focus 2018' assessment provides an overarching description of the relevant situations and security threats within various countries, regions, and themes. The assessments have a time horizon of one year and are published in the first quarter.

The NSM is Norway's expert body on information and object security, and the national specialist authority for ICT security. The NSM produces an annual report on the state of security within the scope of the Norwegian Security Act. In this report, the NSM considers risks applying to vital societal functions and critical infrastructure, information that should be protected and people being impacted by espionage, sabotage, terrorism or other serious acts. The report has a time horizon of one year.

The Norwegian Directorate for Civil Protection (DSB) is tasked with maintaining a general overview of risk and vulnerability within society. The DSB has published risk analyses of scenarios since 2011. The analyses cover risks associated with catastrophic events that could impact Norwegian society and that Norway should be prepared to face. These include natural events, major accidents and intentional acts. The analyses have longer time horizons than the annual assessments of the other three agencies.

[1] *Up until 2016, the DSB's scenario analyses were called 'National Risk Analyses'. Since 2016 they have been called 'Analyses of Crisis Scenarios (year) – Disasters that may affect Norwegian society'.*

CONTENTS

FLOODING:
Two 100-year floods in two years: in May 2013, watercourses in Eastern Norway were once again struck by major flooding. Hardest hit was the settlement of Kvam in Nord-Fron municipality.

PHOTO MATTIS SANDBLAD/VG

Analyses of Crisis Scenarios 2019 (ACS) presents 16 areas of risk, all of which contain hazards or threats that can trigger serious events for Norwegian society. The risk analyses in ACS cover all sectors and levels of government in order to develop an understanding of, and create awareness about, the broad range of potential consequential events and consequences.

Possible risk mitigation measures are presented in each of the 25 risk analyses. Some of these require long-term work and will be challenging to achieve, while for others, processes are already underway and measures have been implemented. The recommendations below are based on the analyses in this report.

Developments in the risk profile
The risk picture is constantly changing. This is due to both societal changes domestically and to external factors affecting us.

One important trend is climate change. Natural events account for a significant part of the risk picture in Norway. Flooding, landslides and avalanches are already frequent incidents, and in the future we must expect these to occur both more often and with greater severity than today. Climate change may also result in many other, and to some extent less predictable, consequences in areas such as security of supply and migration.

Norway is one of the countries that has come furthest in the digitalisation of societal functions, and this trend is continuing unabated. Digitalisation brings with it new vulnerabilities whose depth and scope we do not yet fully understand. There is a sizeable risk that we may be taken by surprise by events because we do not fully understand the threats and risks we face, or have an overview of interdependencies and potential consequential events.

The most significant changes since the previous edition of this report in 2014 have taken place in the international arena. We have to go back to before 1990 to find a more conflict-filled situation than the one we have seen in the last few years. At the same time, we are seeing the weakening of international trade relationships and cooperation in other arenas. The migration crisis in 2015 also clearly demonstrated that the disparity in living conditions between Western Europe and African and Asian countries carries with it the potential for substantial movements of people and the consequential political and social unrest.

The three trends that have been outlined here are also interconnected and affect each other.

Climate challenges
Climate change and the consequences of extreme weather present public safety challenges in several areas. Extreme weather events are occurring more often and with greater severity, and this is a trend we must expect to continue. Climate change is also contributing to greater unpredictability in that it is becoming harder to envisage where events will occur.

Norway is generally a safe country to live in, but not always. Major and minor accidents, crises and other adverse events do happen, and both understanding and dealing with the entire range of possible events is a challenge. One may have to deal with very different types of events in quick succession, such as a drought and forest fire followed by flooding. Often the challenges are also interconnected and affect each other, and some adverse events have profound consequences that span large geographical areas, multiple levels of government and many sectors of society.

Droughts, flooding and sea level rise may result in millions more people leaving their homes to seek a better life in another part of the world. Climate change may also result in serious failures in food production and disruption to world trade. The changes are particularly serious in the Arctic, and this is opening the way for increased activity in this part of the world. Many have pointed out that cruise vessel and oil tanker traffic in Arctic areas present important safety and emergency preparedness issues. These are discussed in the risk analysis in the Collision at Sea scenario.

The most immediate challenges Norway faces are increased precipitation and precipitation intensity, with the associated risks of flooding and landslides. In recent years, many local communities have sustained considerable damage due to flash flooding in smaller watercourses. The analysis of the Flash Flooding in a City scenario describes the extensive damage that torrential rain can cause in an urban area. Cities and built-up areas are vulnerable because natural streams are often diverted into pipes and a large proportion of the land is covered by asphalt and concrete. At the same time, the summer of 2018 in Norway, with the drought in Southern Norway and the consequences of this, such as forest fires and reduced crops, showed the other potential sides of climate change.

The DSB recommends that municipalities take greater account of increased precipitation and the associated higher risk of flooding and landslides in land-use planning. This involves both preventing new building in flood and landslide-prone areas, and developing measures for managing storm water in the event of heavy precipitation.

ICT security
Norwegian society is heavily reliant on ICT, which includes electronic communications. The risk analyses for cyber attacks on electronic communications and financial services infrastructure, respectively, clearly show how extensive this reliance is and how serious the consequences of these functions failing could be. The fact that almost all electronic communications rely on Telenor's transport network is a vulnerability. The Government has therefore started a pilot project aimed at establishing an additional national network for the transmission of voice and data traffic.

Norway is one of the countries in the world where the use of electronic means of payment is most widespread. Cash transactions account for a steadily smaller part of the economy. While this is a desired development that provides obvious benefits in many areas, it also represents a growing vulnerability. New regulations oblige banks to be ready to distribute cash. Nevertheless, there is little doubt that it would be very hard to distribute large amounts of cash to businesses and the public in a crisis situation. It is also difficult to conduct a full-scale exercise for such a situation.

One challenge that applies to all sectors is that it can be difficult to maintain an overview of digital vulnerabilities. Value chains are often lengthy and complex, and failures in one part of a value chain can have immediate consequences for end users. The digital market is volatile. Services are outsourced, subcontractors are replaced and companies are sold or merged. Technological advances happen quickly and changes sometimes take place without all of the consequences being understood. At the same time, there are some dependencies that will always exist, such as the dependence on power supplies. Secure and redundant power supplies are also important for ICT security.

There has been a tendency to regard ICT security as a detached discipline that can be managed separately. The analyses in this report clearly show that the security of information and communications systems is of central importance to public safety. Ensuring that sensitive information does not end up in the wrong hands is just one aspect of ICT security work. It is just as important to ensure that ICT systems and the societal functions of which they are a part are functional at all times.

The DSB recommends that efforts to reduce vulnerability in digital value chains and reduce society's vulnerability from digital systems becoming unavailable be intensified in all sectors of society.

Security of supply
The Supply Failures risk area is a new addition since the last edition of this report. The challenges are described in three risk analyses related to the failure of food grain, drugs and power supplies, respectively. We should be most concerned about the supply of drugs. The production and supply lines for many drugs are long and complex. The active ingredients are largely produced in China and India. Norway has virtually no domestic production of drugs. Situations in which there are shortages as far as supplies are concerned occur frequently. The risk analysis for the Drug Shortage scenario shows that failures in the supply of vital drugs can have very serious consequences.

In the short term there is less reason to be concerned about the supply of food grains, although climate change may over time result in a higher likelihood of failures in world trade in some years.

The DSB recommends that the health sector re-assesses the requirements for wholesalers, pharmacies and hospitals to store drugs, and that mechanisms be established for managing situations involving shortages and possible hoarding. As far as food grains are concerned, the DSB recommends stronger state monitoring of the likelihood of supply failures in the global market.

Attacks on civil society
In the *Aggression by foreign state* risk area, we describe how a foreign power could put pressure on the authorities, for example by exploiting digital vulnerabilities and spreading disinformation via social media and other channels. Such events belong to the grey area between war and peace, where military force can constitute a threat, but is not used. Attacks targeting civil society must primarily be managed by civil actors. Hybrid attacks are characterised by the combined use of means that impact different sectors of society without the links being obvious, or the threat actors identifying themselves. Incidents of this type require extensive coordination between the intelligence and security services and the civil authorities responsible for sectors of society.

The DSB stresses the importance of establishing a common understanding of risks and intersectoral crisis management when hybrid incidents are suspected.

Other challenges that deserve extra attention
Above, we have pointed out a number of areas where we believe that the risk picture is changing, and where it is important to be aware that this also requires changes to our ways of dealing with prevention and emergency preparedness. In other areas, the risk picture is more stable, although this does not necessarily mean that less attention should be paid to them. We have also noted that since 2010 there have been several incidents involving petroleum activities in Norwegian areas that have had the potential to develop into major incidents.

The Petroleum Safety Authority Norway (Ptil) has itself pointed out that even though the total number of adverse incidents has decreased, no corresponding positive development can be seen for the most serious near-accidents.

Similarly, we have noted in recent years that there has been a high number of fires in road tunnels. The risk analysis in the Tunnel Fire scenario establishes that, given the current risk picture, we must regard it as almost certain that a serious tunnel fire will occur in Norway within the space of a few decades. Norway has a very high number of road tunnels and few of them were constructed to meet the safety requirements that apply to new infrastructure today.

Quick clay constitutes a significant hazard in large parts of the country. The risk analysis for the Quick Clay Landslide in a City scenario clearly shows how catastrophic such an event can be in a built-up area. The Norwegian Water Resources and Energy Directorate (NVE) maintains an overview of nine other densely populated areas where quick clay represents a similar challenge. There may also be areas that have not been registered. The hazard quick clay landslides represent can be mitigated by further surveying of vulnerable zones and restrictions on activities where there is a high risk of serious events.

Most school shooting incidents have occurred in the USA, but there have also been cases in Europe. It is not inconceivable that such an incident could occur in Norway. The vast majority of school shootings have occurred in smaller places, so this is not a big city phenomenon. In Norway, the police would in many cases take a lot time to reach the scene. This makes us vulnerable and it is important that schools have emergency response plans and actively work to prevent this type of act.

The DSB recommends that society pays attention to these challenges, not necessarily because they are the most serious, but because there may be potential for further risk mitigation.

Together we are prepared

Many of the crises we have experienced in the last few decades have come as a surprise to the vast majority of people. This is true of the 11 September attacks in the USA in 2001, the tidal wave that struck South Asia in 2004, the volcanic ash cloud crisis in 2010 and the events of 22 July 2011 in Norway.

While risk is always about the future, our perception of risk is always coloured by our experiences and what history tells us. Attention is paid to the major, serious individual events that have occurred before, as if a reoccurrence of earlier events is any more likely than something completely different happening that is at least as serious. Despite this being a well-known problem, it is difficult for us to see beyond this understanding of reality.

The challenge does not just concern the nature of the event, it also concerns its scope and severity. Many of the scenarios in this report are based on events familiar from history. The Pandemic in Norway scenario is largely based on the worst influenza pandemic we know of, namely the Spanish flu in 1918-1919, but we cannot ignore the fact that the next pandemic may be even more serious than this. The most powerful solar storm we know of is the Carrington Flare in 1859, but even more powerful solar storms are conceivable. The same applies to volcanic eruptions. We have taken the Laki eruption in 1783-1784 as our starting point. This had catastrophic consequences in Iceland and for large parts of Europe, but there is no guarantee that an even more powerful eruption than we are aware of from historical sources will not occur.

EXTREME EVENTS ALWAYS RESULT IN EXTREME CHALLENGES FOR THOSE WHO ARE DEALING WITH THEM. DESPITE IN-DEPTH ANALYSES OF RISKS AND VULNERABILITIES, THERE WILL ALWAYS BE FUNDAMENTAL UNCERTAINTY ABOUT WHAT WILL HAPPEN IN THE FUTURE. WE WILL BE TAKEN BY SURPRISE AGAIN.

Can we nonetheless be prepared? Risk and vulnerability analyses, emergency preparedness planning and exercises improve our ability to cope with demanding challenges, even if they are different to what we have analysed and that for which we have practised.

However, regardless of how well one works on public safety and preparedness, it is impossible to eliminate every risk. We have to learn to live with the residual risk, while Norway's emergency responders constantly work together to create a safe, secure and robust society.

Analyses of Crisis Scenarios represents a common starting point for such activities for actors in private and public organisations, across sectoral boundaries and levels of government.

This report can also be used by each of us as a starting point for our own assessments of how we can contribute to society's common preparedness. Together we are prepared. ◎

Cecilie Daae
Director

SUMMARY

TRIDENT JUNCTURE:
Tanks are unloaded in Fredrikstad in connection with the NATO excerise Trident Juncture in 2018.

PHOTO: MOHSSEN ASSANIMOGHADDAM / NTB

Since 2011, the Norwegian Directorate for Civil Protection (DSB) has done risk analyses of serious scenarios that could potentially strike Norwegian society. Up until 2014, the analyses were presented in the annual National Risk Analysis (NRA) report. After 2014, new risk analyses were published in separate, more comprehensive subreports.In 2016, the name of the report series was changed to Analyses of Crisis Scenarios (ACS). ACS 2019 is the first collated report since NRA 2014.

ACS is divided into 16 risk areas. The areas cover the entire risk spectrum from natural disasters to Aggression by foreign state. For each risk area there are one to three risk analyses, a total of 25, based on specific scenario descriptions.

New topics in the 2019 edition of ACS

The method of analysis used in ACS has been in continuous development since the first report was published in 2011. Assessment of vulnerability, uncertainty and transferability are now parameters in the analyses - in addition to assessments of likelihood and consequences.

Analyses of malicious acts do not include assessments of likelihood.

In addition to an assessment of the likelihood that the specific scenarios will occur, ACS 2019 assesses the likelihood of the specific scenario to occur in the country as a whole. This is termed *transferred likelihood, or transferability.*

Eight new risk analyses have been produced since the last collated report in 2014. The analyses from the previous edition of the report have also been reviewed and revised where new information has been received. In addition, some likelihood and consequence assessments have been changed following a critical review.

The overall risk profile

Figure 1 shows the outcome of 21 of the risk analyses in terms of likelihood and consequence. The assessments are scenario-specific, i.e., *transferred likelihood* has not been considered.

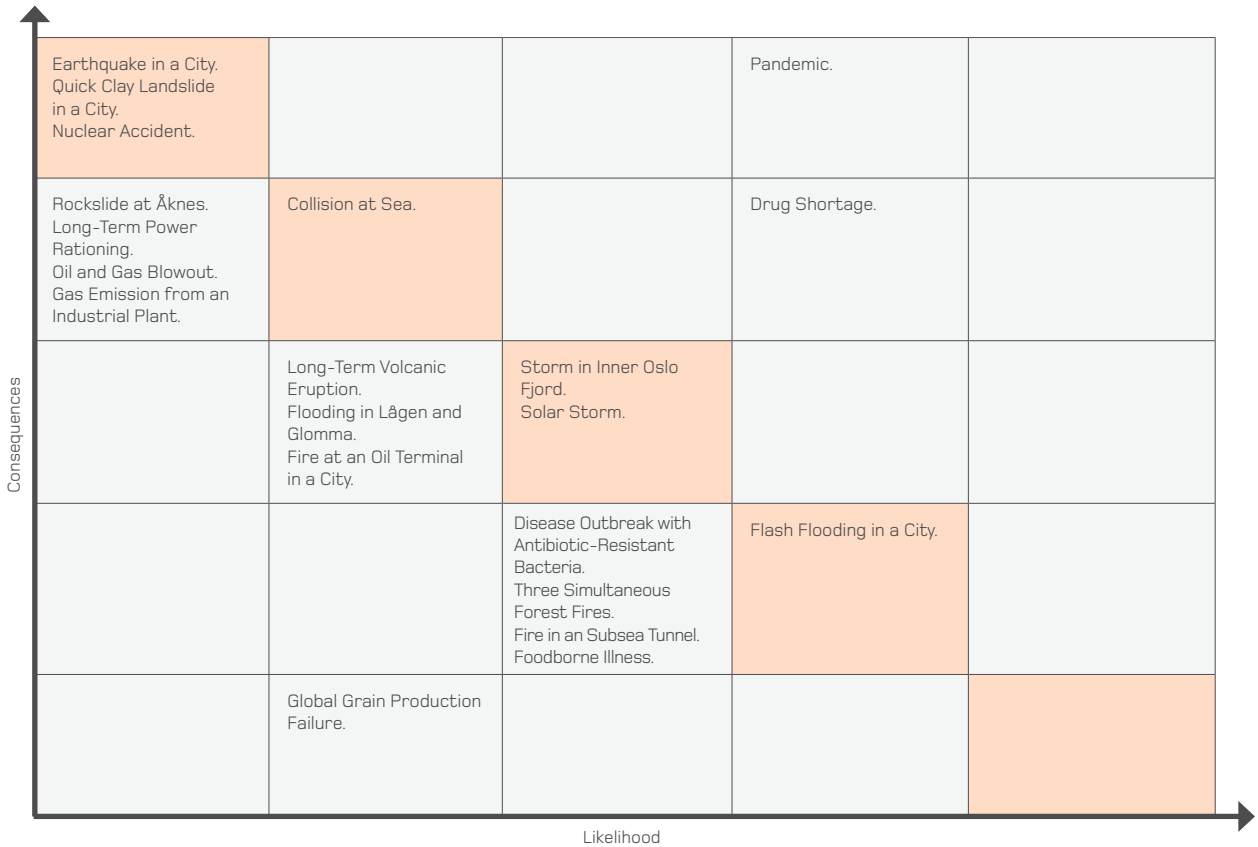


FIGURE 1. Risk matrix with the 21 unintended events in ACS. Intentional acts are omitted in the matrix. Events in the same square have approximately equal risk.

The matrix shows that Pandemic and Drug Shortage are the scenarios with the highest risk. These are followed by the scenarios Earthquake in a City, Quick Clay Landslide in a City, Nuclear Accident, Collision at Sea, Storm in Inner Oslo Fjord, Solar Storm and Flash Flooding in a City that lie along the same diagonal in the middle of the matrix and are assumed to have approximately equal and moderately high risk. Global Grain Production Failure has the lowest risk.

Transferred likelihood on a national basis

Transferred likelihood for the various events in ACS is shown in figure 2 below.

Fire in an Subsea Tunnel, Flash Flooding in a City and Drug Shortage have the highest transferred likelihood. Other events that may occur in several places or in other ways and therefore have a higher transferred rather than scenario-specific likelihood are Nuclear Accident, Large Rockslide and Flooding in Major Waterways.

The events that comprise the greatest risk

The Pandemic and Drug Shortage scenarios score high both in terms of severity and consequence. In addition, there is a large risk associated with a serious nuclear accident and a large rockslide.

Pandemic
The likelihood of a serious pandemic flu is estimated to be 75 per cent over the course of 100 years. The consequences of a pandemic as described in the scenario will be immense, with approximately 8,000 fatalities, 35,000–40,000 hospitalisations, enormous economic losses and social and psychological reactions in the population. Pandemics arise regularly; there were three such events in the 1900s.

Drug Shortage
The Drug Shortage scenario describes an event with an acute shortage of insulin and antibiotics. The likelihood is estimated at 75 per cent over the course of 100 years. Since also a

Transferred likelihood of the scenarios

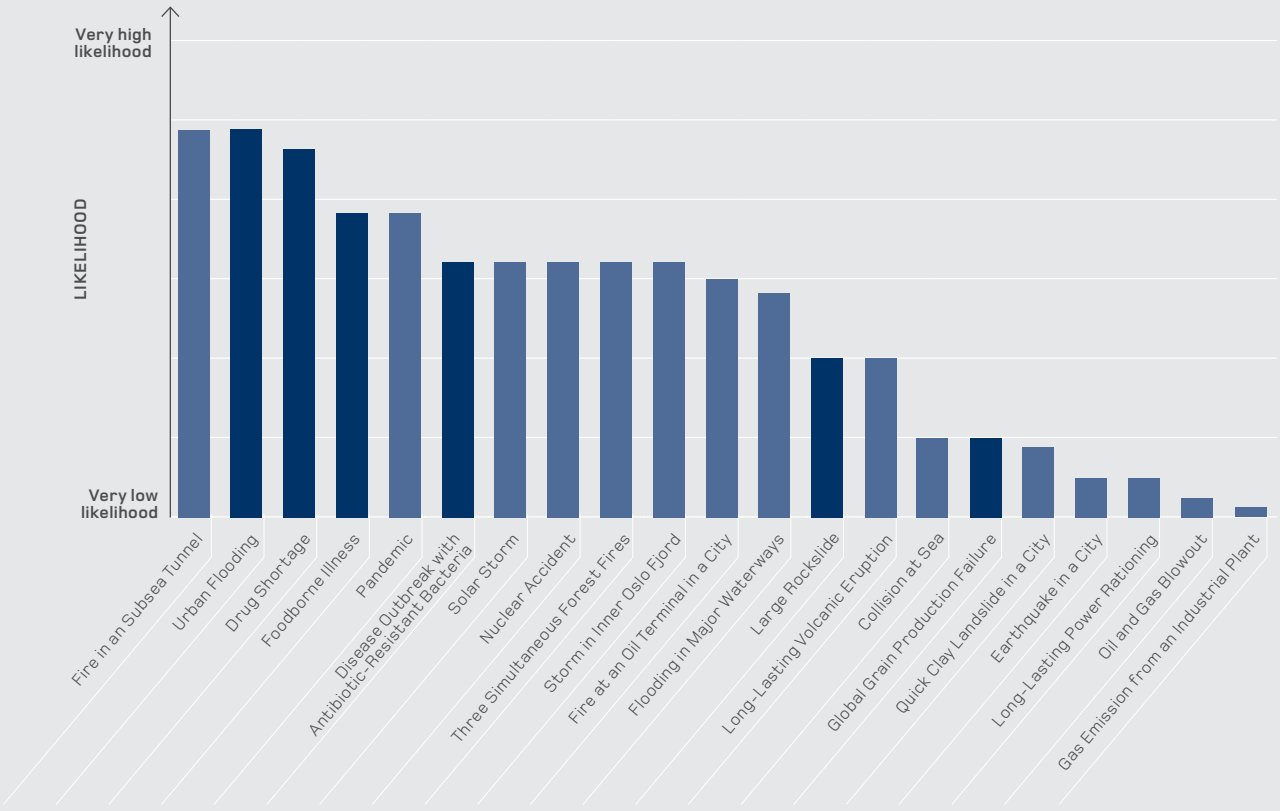


FIGURE 2. Transferred likelihood on a national basis for ACS scenarios. The latest analyses are marked with a darker colour.

lack of other drugs can have serious consequences, the transferred likelihood is estimated to be 90 per cent over the course of 100 years. The scenario will lead to an estimated 2,500 fatalities and aggravate the illnesses of 8,000 people. A lack of vital drugs will also create major turmoil in the population.

Nuclear Accident

The analysed atomic accident in the report is set in the nuclear fuel reprocessing plant in Sellafield in the UK. The specific scenario has very low likelihood (2 per cent over 100 years), but the overall likelihood of a serious nuclear accident with major emissions affecting Norway is considerably greater, estimated at 65 per cent over the course of 100 years, which is moderate likelihood in ACS. An accident at the Sellafield plant will lead to hundreds of fatalities due to expedited death caused by radioactive pollution and several thousands of sick people. The economic, social and psychological consequences will also be great.

Large Rockslide

Because the situation at Åknes is continuously monitored, it will be possible to give advance warning of a rockslide. The likelihood of a rockslide in Åknes with subsequent devastating tsunami wave is estimated to be 2 per cent over the course of 100 years. The likelihood of rockslides in one of the 26 areas is 40 per cent, or moderately high, over the course of 100 years. A rockslide in Åknes with advance warning will have very large consequences in terms of a loss of 26 protected monuments and sites and cultural environments and material damage totalling NOK 10–15 billion. The scenario analysis estimates ten fatalities and 100 severely injured.

Major consequences – low likelihood

Figure 3 summarizes the impact assessment of the ACS scenarios. The colour codes on the columns illustrate the contribution of the different types of consequences on the overall impact.

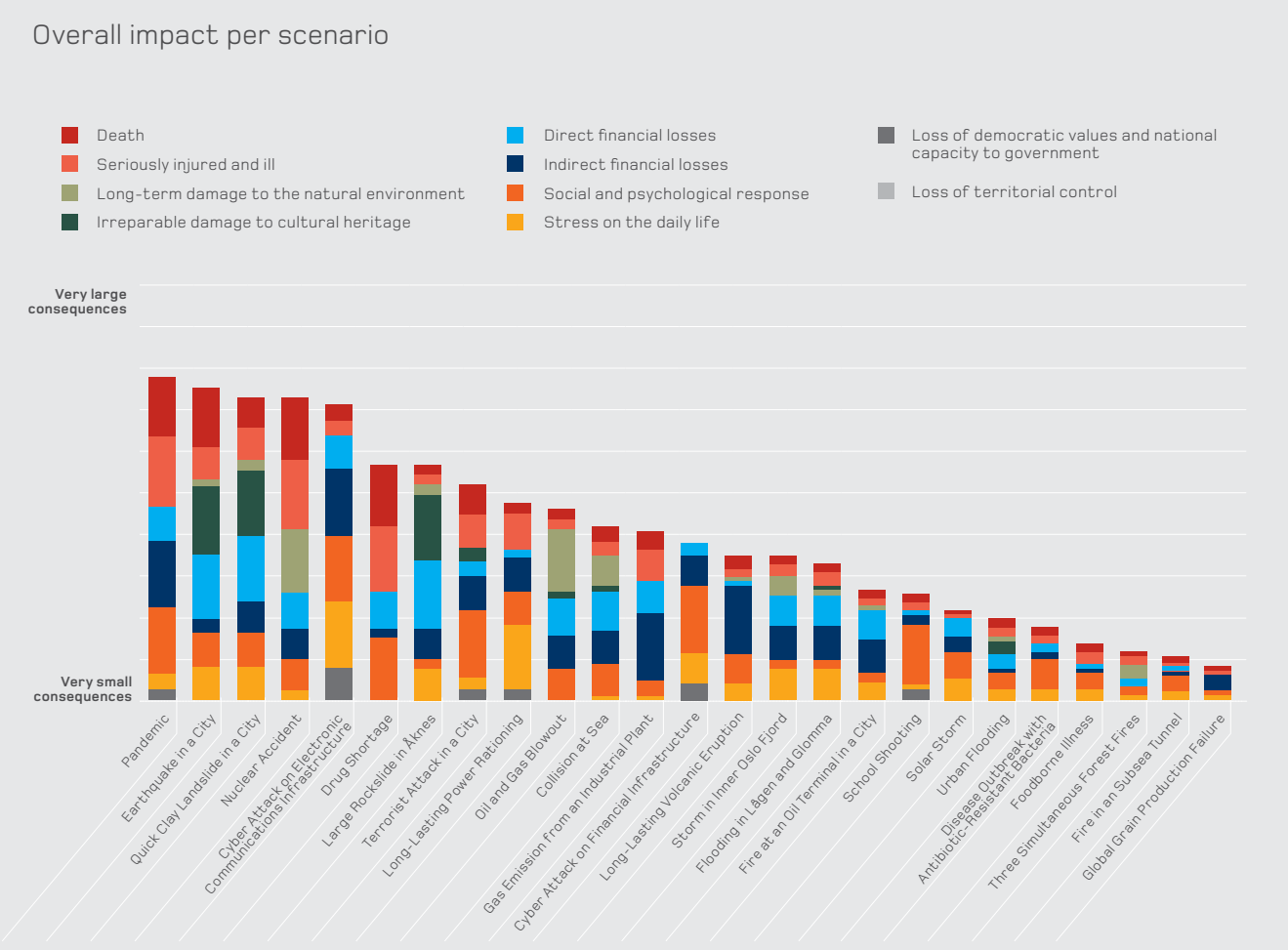


FIGURE 3. Overall impact per scenario, broken down into the eight different types of consequences.

Earthquake in a City
The likelihood of a magnitude 6.5 earthquake in the Bergen area is estimated at 3 per cent over the course of 100 years; the likelihood on a national basis is 10 per cent over the course of 100 years. The analysis shows that an earthquake of this strength in Bergen could have extreme consequences. The estimated death toll is 300, with 500 severely injured. Many protected monuments and sites and cultural environments will be lost and the direct economic losses will be enormous. The event will trigger major social and psychological reactions.

Quick Clay Landslide in a City
The Quick Clay Landslide in a City scenario is set in Bakklandet in Trondheim city. Nine other quick clay zones are registered in densely populated regions of Norway. The likelihood of the specific scenario is estimated at 4 per cent over the course of 100 years. Nationwide, the likelihood of a quick clay landslide in a densely populated area is estimated at 35 per cent over the course of 100 years. The consequences of a landslide on Bakklandet will be enormous. The estimated death toll is 200, with 500 severely injured and ill. Many irreplaceable monuments and sites and cultural environments will be lost and the direct economic losses will also be significant.

Long-Term Power Rationing
Rolling power rationing may be introduced in the event of a shortage of power. The scenario that is analysed is localised in Møre og Romsdal and Trøndelag. The likelihood of this scenario is estimated to be 2 per cent over the course of 100 years, and the transferred likelihood is estimated at 10 per cent over the course of 100 years. The incident will inflict enormous stress on the daily life of the population and cause strong social and psychological reactions. Critical services and deliveries will be hard hit. In addition, major health consequences are expected. The economic consequences will also be large, with losses totalling NOK 10–20 billion.

Oil and Gas Blowout
The likelihood of an incident occurring on the specific drilling installation is very low, estimated at 0.02 per cent over the course of 100 years. However, approximately 200 wells are drilled annually on the Norwegian continental shelf (NCS), and this means that the likelihood of a severe blowout on the NCS is 4 per cent over the course of 100 years. The estimated death toll in the event of an incident is 5–20, with 20–100 severely injured and ill. Long-term damage to the natural environment would be enormous, with oil slicks washing up on 3,000 km of coastline. The economic losses will also be large, and strong reactions in the population must be expected.

Collision at Sea
In the scenario a large cruise ship collides with a tanker. A fire breaks out on the cruise ship and 100,000 tons of crude oil leaks from the tanker. The likelihood of the specific scenario is estimated at 10 per cent over the course of 100 years and 20 per cent over the course of 100 years for a similar event on a national basis. The incident will have a major impact on the natural environment with oil slicks along 1,000 km of coastline and entail major economic losses and major social and psychological reactions in the population.

Gas Emission from an Industrial Plant
The Gas Emission from an Industrial Plant scenario is based on a breach in Yara's ammonia tank at Herøya Industrial Park in Porsgrunn. The scenario has very low likelihood, 1 per cent over the course of 100 years, but will have major consequences should it occur. The death toll is estimated at just under 100, with 500 severely injured and ill. Beyond this, the economic losses make up the majority of the impact.

Events with moderately high likelihood and moderately large impact

An event that has a likelihood of 40–69 per cent of occurring over the course of 100 years falls under the category moderately high likelihood in ACS. Of these events, only a serious nuclear accident and a large rockslide, which are discussed above, will have large or very large consequences. However, several will have a moderately large impact:

- Solar Storm
- Fire at an Oil Terminal in a City
- Flooding in Major Waterways
- Storm in inner Oslo Fjord
- Volcanic Eruption in Iceland

Intentional acts

Below follows a review of the four intentional acts that were analysed. The order is determined by the events' consequences, from most severe to least severe. Likelihood is not considered for such events.

Cyber Attack on Electronic Communications Infrastructure
In the Cyber Attack on Electronic Communications (Ecom) Infrastructure scenario, a resourceful foreign power is able to put Telenor's transport network for electronic communications out of commission for five days. The attack shuts down virtually all electronic communication services, including voice and data traffic and national radio and television broadcasts.

The event will cause 50 additional deaths and serious injury and illness to 200–300 people due to an inability to notify the emergency services. There will also be large economic losses. Reduced opportunities for communication and coordination will challenge central institutions' crisis management capacity, and the event will create major unrest and uncertainty in the population.

Terrorist Attack in a City
The Terrorist Attack in a City scenario describes a coordinated attack by a group of terrorists on the Storting, a hotel and a shopping centre in Oslo. Explosives and firearms are used. The consequences for life and health will be large, with 100–150 deaths and 400–500 severely injured or ill. In addition, large indirect economic losses resulting from a loss of sales, new security requirements, etc. are expected. The event will create huge fear and unrest in the population.

Cyber Attack on Financial Infrastructure
An extensive cyber attack will shut down all payment terminals and ATMs in the country, and all payments must be made in cash. It will take time to get large amounts of cash distributed to the population and businesses. It is assumed that the social and psychological reactions of the population will be very large, not least because of the uncertainty that will be created concerning the stability and security of the financial system. The incident will cause large economic losses for businesses and will be experienced as a major strain in the daily life of the population. Overall, the impact is considered to be moderately large.

School Shooting
The analysed scenario has been situated at a secondary school in the county of Nordland. A student attacks fellow students and teachers with handguns. In the scenario there are 16 fatalities and a total of 50 severely injured or ill. The incident causes very large social and psychological reactions in terms of grief, anger and concern in the population. Overall, the impact is considered to be moderately large.

Overall risk and potential risk reduction

When society prioritises risk-reducing measures, the means that exist, the cost of the actions, and the effects they will have must also be taken into account. This can be described as *potential risk reduction*.

Comparing potential risk mitigation and the risk of events occurring provides a better basis for the responsible authorities that have to make decisions regarding any risk mitigation measures. The DSB suggests seven indicators that can be used to assess the potential for risk mitigation.

DROUGHT:
Crop failure due to drought in Southern and Eastern Norway in 2018. Grain yields were nearly halved, while farmers had to slaughter animals because of a lack of feed.

PHOTO: TERJE PEDERSTAD / NTB

01

AIM AND CONTENT

Analyses of Crisis Scenarios (ACS) describes risk areas and presents risk analyses conducted on a selection of adverse events with disastrous consequences for society. These are events that Norwegian society should be familiar with in order to assess mitigating measures against. This is not because they will necessarily occur just as they are described in the ACS, but because they represent stresses that a robust society must be prepared to handle.

One of the major challenges of serious adverse events today is the fact that their consequences and the management of them cut across areas of responsibility and administrative levels in society. The dependencies between functions in a modern society are so strong that if a single important function is put out of action, problems often propagate to completely different areas.

ACS attempts to illustrate the complexity of the course of events for serious adverse events, and includes consequential events and many types of consequences. The aim is for the actors who are affected by the consequences, or play a role in preventing and managing crises, to have a better overview and insight through the risk analyses that are presented.

Information from ACS can be used in risk and vulnerability analyses, planning processes and exercises at national, regional and local levels, and should be translated into preventive and mitigating measures. In Report to the Storting (white paper) No. 10 (2016–2017) Risk in a Safe and Secure Society, ACS is highlighted as forming part of the knowledge base for public safety work and as constituting, together with the annual assessments produced by the PST, the NSM and the NIS, an overview of "various situations that could threaten Norwegian interests or assets that we want to protect." These assessments can "provide important input for sectors' and organisations' risk management, such that the understanding of risk is improved." The report also points out that "the DSB's crisis scenarios are a good starting point for the municipalities' work on risk and vulnerability analyses."

01.1 Selection of events

The 25 scenarios that are included in Analyses of Crisis Scenarios do not comprise all of the catastrophic events that can occur in Norwegian society. The next event may be one that we have not seen or analysed previously, and therefore it may be completely unexpected when it occurs. Nevertheless, the DSB believes that if Norwegian society is prepared to meet the events that have been analysed in ACS, it is also prepared to meet many other events.

Analyses of Crisis Scenarios encompasses a broad selection of events: natural events, major accidents, supply failures and intentional acts. Analysed events are chosen by the DSB in dialogue with ministries, directorates and other stakeholders.

Common to all of them is the fact that:

- they have consequences affecting several important societal assets
- they can have disastrous consequences and require extraordinary input from the public authorities
- the consequences and management of the event transcend sectors and areas of responsibility and require cooperation
- the conditions must indicate that they can occur tomorrow

We understand a crisis scenario as being an adverse event for which we are not certain we are prepared. The event challenges society's risk management capacity. The scenarios that are analysed are in other words very serious, but they are not inconceivable or unrealistic. A storm or forest fire will normally have far fewer consequences than the scenarios described in ACS. ACS can thus not be used directly to dimension emergency preparedness, but it can be used as the basis for evaluation of what the current emergency preparedness can manage.

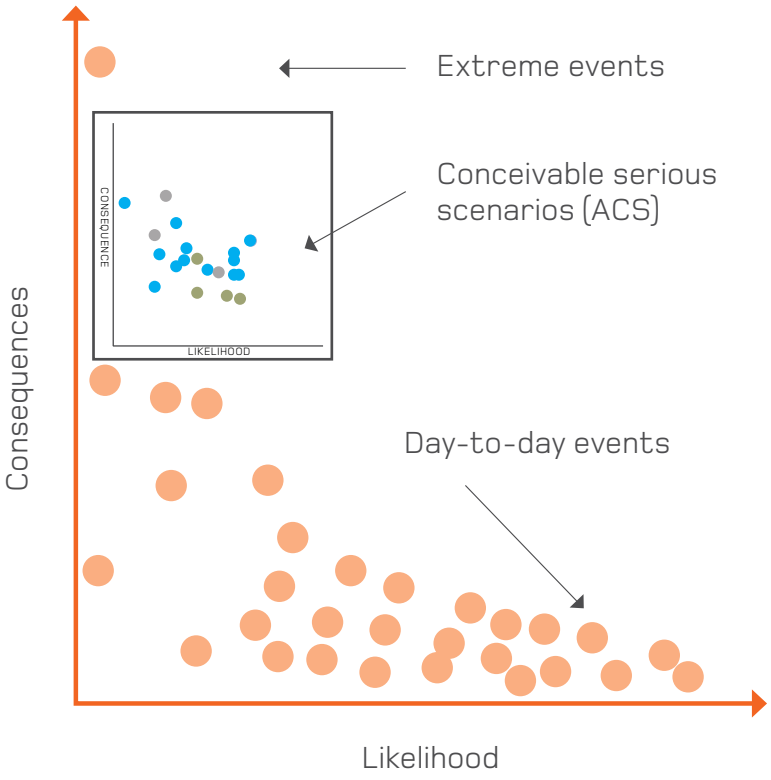


FIGURE 4. The scenarios that are analysed in ACS are very serious scenarios – not day-to-day accidents, but neither not the most extreme events imaginable either.

01.2 Use of *Analyses of Crisis Scenarios*

ACS urges societal actors at all levels to answer three important questions:

1. *How will my sector, county, municipality or organisation be affected by the events that have been analysed?* Most events involve a host municipality and a host county that must manage some of the consequences locally. However, all events cannot take place everywhere. Where can a collision at sea or landslide occur?

   Events also come under the area of responsibility of one or more sectoral public authorities. What events are relevant for separate risk analyses and emergency planning? How do the various events impact power supply, water supply and the usability of the road network? What means are available to us to reduce the risk?

2. *Which of the major events with national consequences should be scaled down based on local conditions to less serious events that will nevertheless be a disaster for the local community?* A weaker storm, a smaller fire or landslide, are possible examples. An assessment should be made as to whether all the national events that are analysed in ACS should be included in a scaled-down form in local or sectoral risk analyses or emergency preparedness plans.

3. *How can my organisation help to prevent the events or mitigate their consequences?* What means are available to us?

The basis for risk management across sectors and administrative levels

Both the scenario descriptions and risk analyses may provide important input to county risk and vulnerability assessments, comprehensive risk and vulnerability assessments in municipalities and risk analyses in government sectors.

The instructions for the ministries' work with civil protection and emergency preparedness (established by the Norwegian Ministry of Justice and Public Security on 1 September 2017) require ministries to *"compile and maintain systematic risk and vulnerability analyses based on assessments of intentional and unintentional incidents that may threaten the ministry's and sector's functionality, and represent a risk for life, health and material assets."*
It is further stated that this analysis shall be based on principal national bases for planning such as ACS.

The Act relating to Municipal Emergency Preparedness, which entered into force on 1 January 2011, states that the *«Municipalities are required to survey the adverse events that may occur in the municipalities, assess the likelihood of these events occurring and how their possible occurrence may affect the municipalities. The results of this work must be assessed and collated in a comprehensive risk and vulnerability analysis.»*

The consequences of certain adverse events are so extensive that several administrative levels and sectors in society are affected. Thus, there is a danger of making the risk analyses too narrow within one's own area of responsibility, not seeing all the dependencies and interfaces with other actors. The risk analyses in ACS transcend sectors and may include all of the administrative levels to extract knowledge and create awareness of the broad range of consequential events and consequences. Such a broad process is also important in more local and sectoral risk analyses. An analysis across sectors and levels can identify the consequences of consequential events in completely different social areas than where the initial event took place.

For example, a powerful storm will result in direct damage that the local authorities must manage. However, a storm may also have consequential events, such as power outages, closed roads, railways, ports and airports, loss of telecom and data communications, etc. These are consequential events which the public authorities often have a responsibility to manage. Both the direct and indirect consequences of the adverse event should be included in risk analyses to attain a comprehensive view of the risk. Within prevention, warning, management, rescue and rebuilding, there is a need for cooperation across areas of responsibility.

Target groups

The main target group for ACS are those who may benefit from the risk analyses in their emergency planning, their own risk and vulnerability analyses and exercises. At the same time, in society as a whole the need for knowledge about risk differs, and ACS can provide important input on different levels to work on prevention of adverse events and mitigation of the consequences of them. ACS can also help to strengthen the general public's understanding of risk.

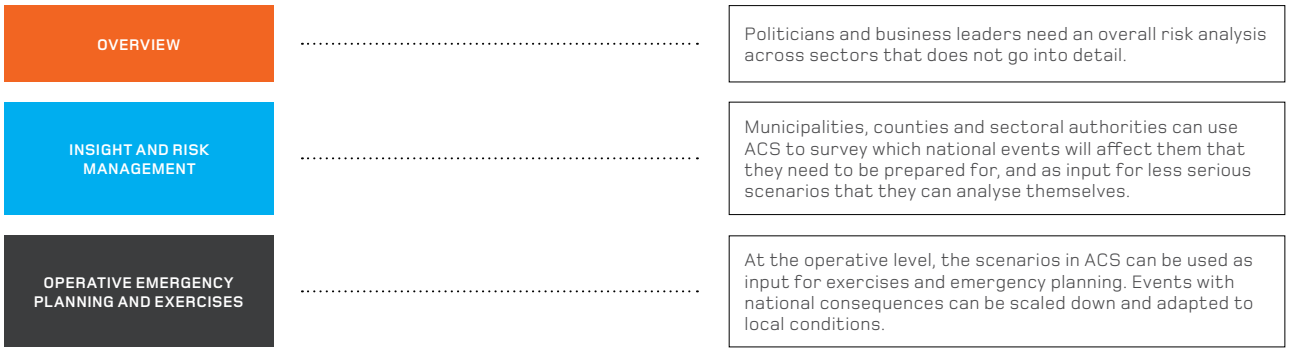


FIGURE 5. Figure that illustrate different needs for knowledge of risks in society.

Analyses of Crisis Scenarios 2019 (ACS) is a collated report in which all of the 25 risk analyses conducted since 2010 have been collated. Such collation can provide a useful overview of very different events that can be included in others' risk and vulnerability analyses. At the same time, the discussion of the individual risk analyses will by necessity be brief. For more comprehensive descriptions of the risk analyses conducted since 2014, please refer to the subreports published for each analysis. The subreports provide a good knowledge base for understanding the phenomenon analysed in the specific risk analysis and are useful for actors that require a deeper understanding of the adverse events that have been analysed.

Improved risk awareness

The report from the 22 July Commission states that: "The understanding of risk provides the basis for which measures are implemented and is guiding for the level of safety, security and preparedness society chooses to have."[2] National risk analyses such as ACS can create both support and opposing views, but in both cases it contributes to greater awareness and discussion of risk in society. Discussing and analysing risk increases the level of knowledge and comprehension of dangers, vulnerabilities and uncertainty. By thinking through what can possibly happen, and understanding the development of serious, adverse events and what consequences they may have, we will be better prepared to meet disasters when they arise.

There will always be a discussion of whether the right events are included in a selection of crisis scenarios, whether the assessments of likelihood and consequences are precise enough, etc. No one can state with certainty what the risk related to a specific event in the future is. The utility value of the risk analyses that are conducted in ACS lies just as much in the description of the risk areas, the course of events and consequences as in the "size" of the risk or the placement in the overall risk matrix.

Structure of the report

The report is divided into three sections: an introduction, an analysis section and a summary section. Section 1 in the report discusses the aim of Analyses of Crisis Scenarios, its content and scope, the target groups and the use of ACS. Section 2 explains how DSB defines the key terms that are used in the report, as well as the methods and procedures used as a basis for the preparation of ACS.

Sections 3–18 comprise the analysis section, which is divided according to risk areas with the associated adverse events. One or more scenarios are analysed for each of the risk areas, and the results are presented individually. Overall, a total of 16 risk areas and 25 scenario analyses are presented in the report.

The last section of the report looks at the 25 risk analyses altogether and discusses similarities, differences and patterns. The result of the analysis for the unintentional events are presented in a risk matrix based on likelihood and consequences.

[2] *Official Norwegian Report 2012: 14 Report from the 22nd of July Commission.*

POWER SUPPLY:
The societal function Power Supply includes the systems and deliverables necessary to address society's need for electricity for heating, housekeeping, production, transport, etc., as well as district heating if such systems have been installed. Vital functions in society, DSB 2017.

PHOTO: SAMPHOTO/THORFINN BEKKELUND

02

METHODOLOGICAL APPROACH TO RISK

Risk analyses can be conducted in various ways and the methodological choices and understanding of concepts are crucial for how risks are analysed and presented. This chapter describes important methodological choices in ACS, the elements included in the risk analyses and our understanding of the concepts.[3]

2.1 Methodological choices

The purpose of the analyses and available source data generally determines the methodological choices that are made.

Social science approach
The risk analyses in ACS take a social science approach and are based on qualitative data, expert assessments and broad participation in the analysis processes. In some analyses, especially of natural events, technical and natural science methods and quantitative data are also used, especially in calculations of likelihood. There are two factors that indicate a broad social science approach should be used to ACS:
1) We are analysing rare events with limited source data.
2) The consequences are assessed as losses of various societal assets, and in large these must be qualitative assessments.

The analysis results in ACS are subjective assessments based on the background knowledge of those making the assessments. Nobody knows what the true 'objective risk' will be in the future. However, who is assessing the risk does matter. The use of relevant professional expertise in the process is crucial for the quality and legitimacy of the analysis. Verifiability is another quality requirement for the analyses.

THE ANALYSES OF CRISIS SCENARIOS MUST BE CHARACTERISED BY KNOWLEDGE AND VERIFIABILITY.

All assumptions and reasoning must be documented, and uncertainty described through, among other things, an assessment of the knowledge base.

Use of scenarios
The events analysed in ACS are developed into detailed scenarios in order to identify and delineate the analysis object. They are described as specific courses of events, placed in time and space, with a specified scope (e.g. wind speed, precipitation amount and duration). Some scenarios lend themselves to being described in the form of short stories (e.g. School Shooting and Flash Flooding in a City). Scenarios are used because they enable more specific indications of likelihood and consequences than would be the case if we would have analysed more general events. For example, a risk analysis is more precise when one analyses a specific storm rather than storms in general.

The choice of analysis object is often based on a larger area of risk (e.g. extreme weather) which is narrowed down into an event and developed into a detailed scenario, as illustrated on the following page.

[3] *The report "Fremgangsmåte for utarbeidelse av Nasjonalt risikobilde (NRB)" from 2015 describes the method in more detail. A revised method description for ACS will be developed.*

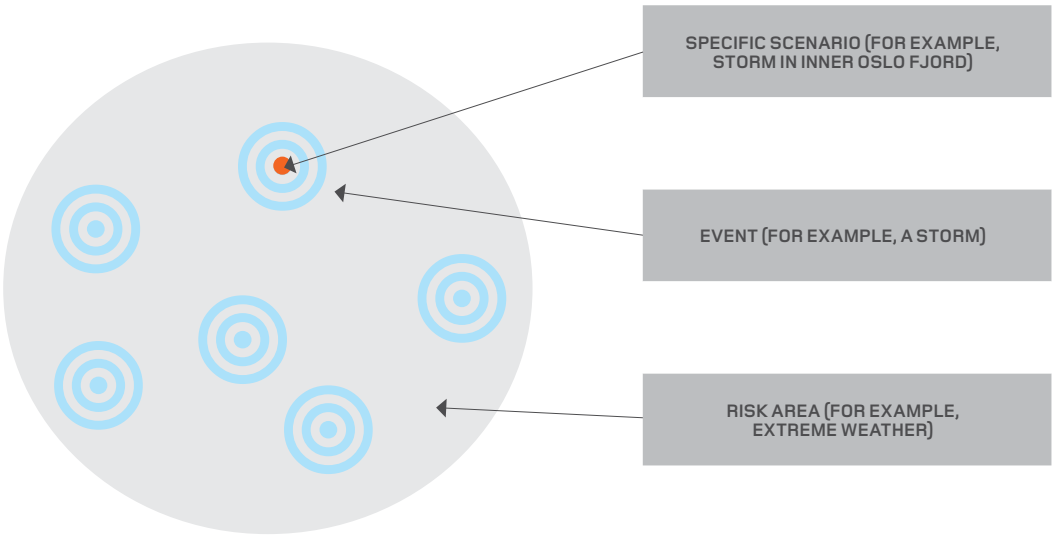


FIGURE 6. The figure illustrates the relationship between risk areas, adverse events and scenarios.

The disadvantage of analysing a specific scenario rather than more general events is that, strictly speaking, the results of the analysis only apply to one of many possible variants of the event. However, the generalisability of the scenario is discussed under the assessment of sensitivity in each analysis. We also state the likelihood, both of the specific scenario occurring and of similar scenarios occurring on a national basis.

The events that will be analysed are selected by the DSB in dialogue with ministries, directorates and other stakeholders. Both internal and external suggestions are assessed based on a set of criteria that is described in more detail in chapter 1. The most important criteria is that the event must potentially have very severe consequences for the public (defined as societal assets), represent a challenge to existing emergency preparedness and not be completely inconceivable.

Analyses of intentional acts

ACS covers a wide range of events: natural events, major accidents, supply failures and intentional acts. All of the events are analysed in the same way, apart from the fact that we do not assess likelihood of the four intentional acts covered by the report. Calculating people who try to circumvent safeguards in order to cause the greatest possible damage are behind such intentional acts. It can be difficult to discern their intentions. Therefore, assessments of the likelihood of intentional acts occurring, heavily depend on the specific threat actors, where the assessments to a large extent are based on intelligence information and other continuous information gathering. However, factors that may influence the likelihood of an intentional act occurring are pointed out and reference made to the relevant threat and risk assessments from the PST, the NSM and the NIS.

Analysis model

Risk is about what might happen in the future and, therefore, always associated with uncertainty. The uncertainty is related to whether a specific adverse event will occur and the consequences such an event would have. In order to gain a methodological understanding of what the risk assessments are based on and to facilitate communication, it may be appropriate to use a stylised analysis model.

The main elements in ACS's risk analyses are likelihood, vulnerability, consequences and uncertainty. The analysis method is based on NS 5814: 2009 Requirements for Risk Assessment[4], but it has been expanded with assessments of vulnerability and uncertainty.

The analysis model in ACS can be illustrated using a diagram that shows the course of events both before and after the event has occurred, including the various assessments that are made in the analysis. This is often referred to as a 'bow tie diagram'.

[4] *The standard is under revision.*

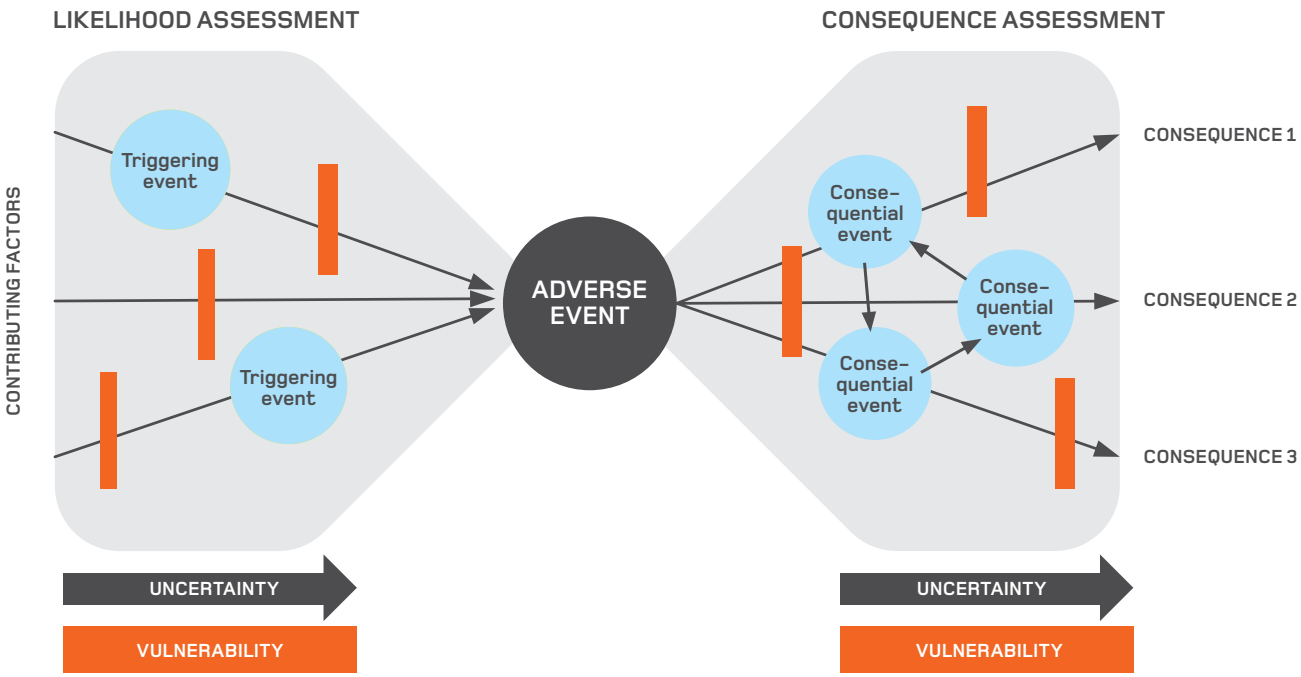


FIGURE 7. Bow tie model illustrating which assessments are made in different parts of the course of events.

The advantages of the bow tie diagram are that it describes a timeline for the course of events and that it can include a number of events both before and after the adverse event that is the main focus of the analysis. Both the triggering events and the consequential events are included in the vulnerability assessments of the system and can identify factors (and possible measures) that indirectly affect both the likelihood of the main event occurring and its consequences. Uncertainty associated with both likelihood of the event occurring and its consequences is assessed.

SCALE FOR PROBABILITY OVER THE COURSE OF 100 YEARS	
Very high	90–99 %
High	70–89 %
Moderate	40–69 %
Low	10–39 %
Very low	0–9 %

TABLE 1. Likelihood intervals used in ACS.

2.2 Understanding of concepts

The key concepts used in the risk analyses in ACS are explained below. Understanding the concepts is crucial to understanding the results of the risk analyses.

Likelihood

We use likelihood to express how likely it is that a specific event will occur during a certain period of time given our knowledge base. In ACS, we assess the likelihood that an event will occur within a 100-year period as a percentage. Since the analyses in ACS concern very serious and rare events, a 100-year perspective for likelihood provides a larger and more readily understood figure than an annual likelihood. Frequencies (event/period of time) have also been used in previous editions of ACS, but these have now been converted to likelihood. The indication of likelihood is divided into five intervals on a scale ranging from very low to very high likelihood.

The intervals were chosen to illustrate the range of likelihood estimates in a 100-year period.

The reasoning and likelihood calculations used in ACS are largely based on *the Norwegian Defense Research Establishment report* "Likelihood and uncertainties – clarification of concepts in connection with risk assessments."[5] A frequency of once in a 100-year period corresponds to an annual likelihood of 1%, or approximately 65% likelihood in a 100-year period. In other words, it is highly likely that the event will occur, but not 100% certain. The 'likelihood curve' is not straight over time, rather it decreases towards the end of the period (the likelihood of the event not happening increases).

When we estimate likelihood in a 100-year period, it is important to understand that we are basing this on current social and climatic factors. When climate change has been taken into account, we explicitly state this (e.g. in the analysis of Flash Flooding in a City).

We estimate two different likelihoods in the analyses. One is the likelihood that the specific scenario being analysed will occur. The other is the likelihood of this type of scenario occurring on a national basis. Given that the scenarios are very specific (a given course of events in a specific location), the likelihood of them occurring will always be relatively low. But it can be just as interesting to look at the likelihood of similar events occurring in the country as a whole. We call this 'transferred likelihood'.

Vulnerability
The traditional definition of vulnerability used in public safety is given in Official Norwegian Report 2000:24 "Vulnerability is a way to express the problems for a system to function when it is exposed to an adverse event, as well as the problems the system will experience in resuming its functionality".

A system could be a technical infrastructure, a value or production chain, an organisational entity or a community on a local, regional or national level. The vulnerability of a system influences both the likelihood of the event occurring and the consequences it would have. The two questions asked in the vulnerability assessment are: 1) What ability does the system have to withstand the adverse event? 2) What ability does the system have to withstand the adverse event?

The opposite of vulnerability is often referred to as robustness or resilience. Robustness and resilience often have slightly different meanings in professional literature.

Robustness is associated with something static, strong and resistant, such as physical barriers, regulations and planned emergency preparedness for known events. Resilience, on the other hand, is associated with a more general and dynamic ability to withstand stress, for example via a flexible and adaptable organisation.

The vulnerability assessments in ACS include the system's resistance, tolerance and ability to resume its functions. The overarching question is the extent to which the system exposed to an adverse event is able to retain its ability to function. The question is operationalised via what its ability to function depends on, the reliability of these deliveries, the system's complexity or transparency, whether effective barriers and redundancy exist, and whether the event triggers subsequent events such as failures of critical societal functions. This report presents brief versions of the vulnerability assessments. Where there are subreports published for individual analyses, the vulnerability is described in more detail.

Consequences
The consequences assessed in ACS are the effects the adverse events would have on given societal assets. These societal assets are defined on the basis of a population perspective. Consequences that are not noticeable to the public – but which may have an impact on an organisation – are not covered in ACS. For example, an ICT failure in a ministry would not be included as long as the public is not impacted by the failure or the consequential events resulting from it.

Five societal assets were defined prior to the first edition of the NRA in 2011 and have been used ever since. However, they have been adjusted and clarified to some extent over the years based on the lessons learned from the analyses and events that have occurred.

The consequence type Social Unrest was replaced by Social and Psychological Response after 22 July 2011 in order to better capture reactions among the public after the terrorist incident. Nature and Environment is now operationalised as Nature and Culture. Economic losses has been split into Direct and Indirect economic losses. Because of these changes, all of the scores in the previous risk analyses have been reviewed as part of the work on ACS 2019. This has resulted in some minor adjustments, upwards and downwards, to the scores in NRA 2014, such that the analyses are now more consistent.

[5] *Odd Busmundrud, 2018: Sannsynligheter og usikkerheter - Begrepsavklaring i forbindelse med risikovurderinger, FFI-report 18/0258, Norwegian Defence Research Establishment.*

The societal assets have each been operationalised as two consequence types, and these have been assessed as concretely as possible.

1. Life and health
   - Fatalities – number of
   - People affected by serious injuries and illnesses – number of
2. Nature and culture
   - Long-term damage to the natural environment – area affected and duration
   - Irreparable damage to the cultural environment – scope of damage to cultural heritage sites and cultural environment
3. Economy
   - Direct economic losses – reconstruction costs and compensation
   - Indirect economic losses – lost production/earnings
4. Societal stability
   - Social and psychological response – among the public: indicators such as shock, anxiety, etc.
   - Stress on daily life – outages of power, electronic communications, transport, etc.
5. Democratic values and capacity to govern
   - Loss of democratic values and national capacity to govern – threats against basic values in society, etc.
   - Loss of territorial control – loss of sovereignty

The various consequence types were scored on a five point scale from very small to very large consequences. The threshold values between the categories are stated as a specific number, scope and so on. The overall consequence for each scenario is a weighted total of the scores for the ten consequence types and have been placed on a separate scale of one to five.[6]

Uncertainty

Assessments of uncertainty in ACS are based on the *knowledge base* for the analysis and the *sensitivity* of the analysis results' to changes in the assumptions. The knowledge base encompasses the understanding of the phenomenon being analysed (explanatory model), the empirical source data and experience of similar events. The knowledge base can be both written and oral, as well as quantitative and qualitative. When assessing uncertainty, the strength of the knowledge base of the risk analysis is evaluated , which has an impact on the credibility of the analysis results.

Sensitivity is assessed on the basis of whether small changes in some of the assumptions will result in significant changes in the analysis results. In particular the assumptions used in the actual scenario are assessed, although the basic assumptions in the reasoning in the analysis are also assessed. The assessments of sensitivity often point out vulnerabilities that are of major significance to both likelihood and consequences.

In ACS, we have chosen to take account of both the knowledge base and sensitivity in the overall assessment of uncertainty. A high level of uncertainty means that the likelihood and consequences may be greater or smaller than stated, and this can influence subsequent decisions. For example, there may be a need for more knowledge and greater certainty before one decides to implement comprehensive measures.

2.3 Analysis process

The risk analyses in ACS involve three main phases:

- Information collection: Collection of relevant knowledge and data about events and the system being analysed. Common sources are public documents and reports, research and meetings with responsible authorities and professional groups.
- Analysis seminar: An expert seminar with participation from the affected authorities and levels of government, research institutions, etc. The seminar assesses likelihood, consequences, vulnerability and uncertainty based on the documentation obtained during the preceding work.
- Processing and quality assurance: Summarising and structuring of the knowledge developed in the preceding work and seminar in a draft report, which is circulated to seminar participants and optionally others, for comment and quality assurance.

FIGURE 8. The analysis processes in ACS involve three main phases and often take a year in total to carry out.

[6] *See the report "Fremgangsmåte for utarbeidelse av Nasjonalt risikobilde (NRB)" on www.dsb.no for more details.*

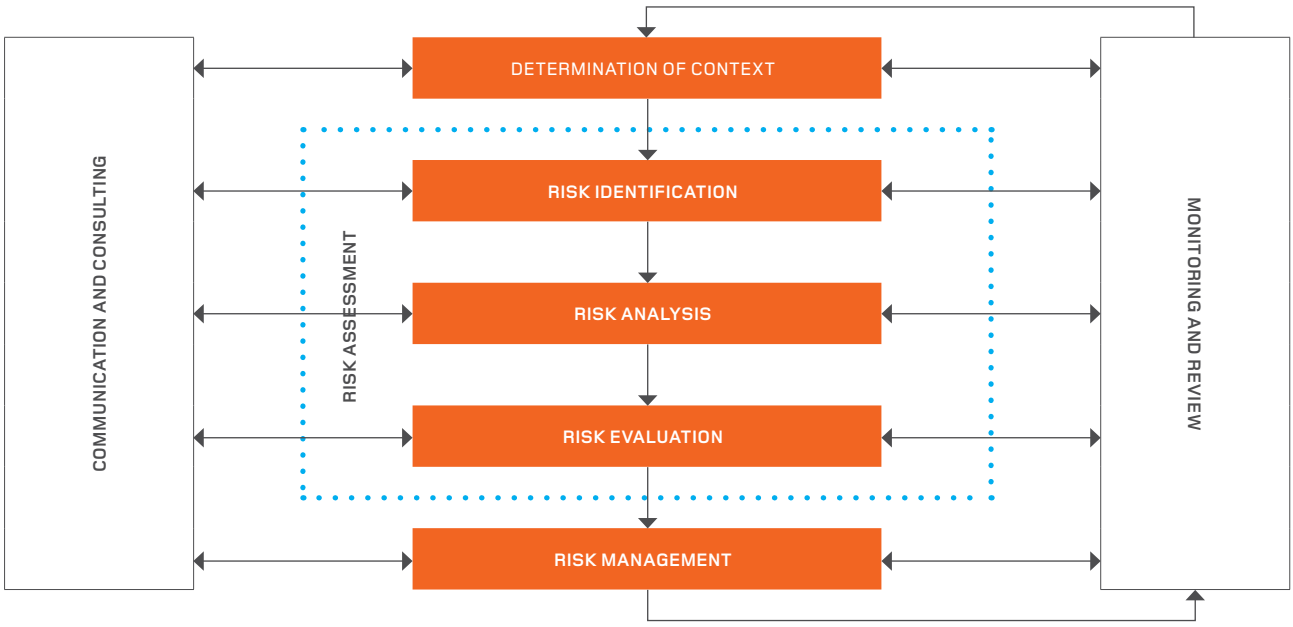


FIGURE 9. DSB's illustration of the risk management process based on NS-ISO 31000: 2018 Risk management – Guidelines.

Expert seminars were chosen as an important element of the analysis processes due to the need to reveal and exploit knowledge that may be 'unspoken' and not documented in writing. At the seminars, different perceptions are highlighted and can be honed in relation to each other in an effective and constructive manner. Not least, it has been our experience that such seminars develop new knowledge and a common understanding of risk among the participants.

Risk management

Risk management encompasses the entire management process from defining the system being analysed, identifying hazards and events, conducting risk analyses and assessing whether risks are acceptable, to making decisions about any risk mitigation measures. In other words, risk analysis is just one of the elements of the management and decision-making process, and is of limited significance on its own.

The risk analyses in ACS primarily cover the first three steps of the risk management process. The risk uncovered is not evaluated, although possible measures are discussed, and an approach towards assessing their potential risk mitigation effects is discussed in chapter 19. It is the sector and specialist authorities for the various areas of responsibility in the analyses that must assess the risk acceptance and which measures should be implemented, and possibly present these for political consideration. ◎

FLOOD:
Floods in parts of the village of Feda in Kvinesdal municipality in 2015.

PHOTO TOR ERIK SCHRØDER / NTB SCANPIX

03

EXTREME WEATHER AND FLOODING

Background

Extreme weather events can include strong winds, torrential downpours, high water levels (possibly with high waves), droughts, heavy snowfall, or a combination of weather elements that together constitute a risk, but which alone do not meet the criteria to be designated as extreme weather. The Norwegian Meteorological Institute (MET) issues an extreme weather warning when it is likely that the weather will cause extensive damage or a risk to life and property in an area, such as a region, county or a large part of a county.

In recent years, several countries around the world have been hit hard by natural disasters and extreme weather events. On a global scale, the financial losses from natural disasters was estimated at USD 314 billion in 2017, the highest ever.[7] The losses were generally caused by severe storms, hurricanes, forest fires, flooding and other weather-related events in North America, the Caribbean, and Europe.[8]

Between 1980 and 2017, 77 per cent of losses inflicted by natural disasters in Norway were due to storms, and storm damages accounted for 56 per cent of compensation payouts. 15 per cent of losses inflicted by natural disasters were due to flooding, and these accounted for 31% of compensation payouts.[9] Climate change is expected to cause more extreme weather events in the coming years.

Storms and hurricanes

The 1992 New Year hurricane which hit the Nordmøre area killed one person and is one of Norway's worst natural disasters of all time in terms of lost assets. The hurricane caused damages to 50,000 to 60,000 buildings, and there was also considerable damage to infrastructure, cultural assets, aquaculture facilities and to forestry. The power outage led to considerable loss of output for the economy, and in some places provisional emergency energy solutions were brought into use for a long time. The financial losses are estimated as being close to NOK 2 billion, after subtracting deductibles and losses due to operating problems.[10]

Storm Gudrun in January 2005 is considered the most destructive storm that has hit Scandinavia in modern times. In Sweden, which was hardest hit, 18 people were killed. Approximately 730,000 inhabitants lost power, and large areas of forest were destroyed. The costs caused by the storm to economic life and the public sector are estimated at approximately NOK 20.8 billion.[11]

---

[7] *"Natural disasters in 2017: Lower mortality, higher cost", Cred Crunch March 2018, Centre for Research on the Epidemiology of Disasters (CRED).*
[8] *Sigma, Swiss Re. No.1/2018 Natural catastrophes and man-made disasters in 2017: A year of record-breaking losses.*
[9] *http://www.nft.nu/nb/node/2194*
[10] *https://www.met.no/nyhetsarkiv/25-ar-siden-den-historiske-nyttarsorkanen*
[11] *Swedish Civil Contingencies Agency (MSB), Krishantering i stormens spår. Sammanställning av myndigheternas erfarenheter [Crisis Management after the Storm. Compilation of the Authorities' Experience]. KBM Report 2005. (www.msb.se)*

In December 2011, Storm Patrick (Dagmar) hit Norway, Sweden and Finland, with winds above hurricane strength. In terms of wind speed, Patrick (Dagmar) was not as strong as the New Year hurricane of 1992, but wind combined with high water levels nevertheless caused severe material damage. Compensation payments for damages caused by natural events were estimated at NOK 1.4 billion.[12] The electricity supply was hit with a total of 570,000 customers losing power, of whom 35,000 had no power for more than 24 hours.[13] The storm also led to a loss of Internet connections and landline and mobile phone networks for many thousands of customers. There was reduced coverage in parts of the emergency communication network in the counties of Akershus and Buskerud as a result of power outages.

Patrick (Dagmar) also caused major problems on the roads and public transport systems. Many main roads and minor roads were closed, ferries were out of service and entire sections or partial sections of several main railway lines were closed. This gave rise to extra challenges for both the grid companies' restoration and fault repair work, and for the municipalities' management of the event.

In January 2018, the counties of Møre og Romsdal, Trøndelag, and southern parts of Nordland were struck by Storm Cora. The average winds reached hurricane strength on both the coast and in the mountains, and there were strong gusts inland as well. While Storm Cora did not cause as much damage as the New Year Storm Dagmar, it is still one of the strongest storms seen in this area in the last few decades.[15]

Flooding and precipitation

Traditionally, the term 'flooding' is used to describe massive water flow in watercourses due to precipitation and snowmelt, and when rivers and streams breach their banks. The weather commonly causing severe flooding varies from region to region. In Western and Northern Norway, flooding is usually caused either by the remnants of tropical cyclones, or by a high pressure area over the United Kingdom and the Continent, with a strong westerly wind north of the high pressure area. In Southern Norway and near the coast of the Oslo Fjord, severe flash flooding coincides with low pressure close to the United Kingdom. In Eastern Norway, low pressure tracking from the south or south-east gives rise to the most dangerous flooding.

Urban flooding occurs when sudden torrential downpours lead to flooding in densely populated areas, where buildings and paved streets and parking lots prevent water from finding natural routes into the terrain. Most flood damage in densely populated areas is caused by torrential downpours lasting from ten minutes to a few hours.

At the end of October 2014, heavy rain even at high elevations in the mountains resulted in major flooding at several locations in Western Norway. Hardest hit were the inland areas of the counties of Hordaland and Sogn og Fjordane, where the Flåm River in Aurland Municipality, the Vosso River in Voss Municipality, and the Opo River in Odda Municipality saw some of the highest water flows that have been recorded for these rivers. The E16 highway and the railway between Oslo and Bergen were closed for several days, several bridges were washed out by the flood and many sections of road and several tunnels were closed due to flooding, landslides and the risk of landslides. Many houses were destroyed by the water, and approximately 500 persons were evacuated.

In May 2013, the Gudbrandsdalen valley was hit by major flooding caused by snowmelt and the subsequent intense period of precipitation over a three-day period. Flooding, landslides, and erosion resulted in highway E6 and the railway line being closed. In some areas, almost all of the roads were destroyed, and one settlement and several farms were isolated. A total of 220 persons were evacuated. The flooding events resulted in long-term closures and the need of major repairs. The socio-economic costs have since been calculated as amounting to at least NOK 1.1 billion and include reconstruction costs associated with municipal infrastructure, the railway network and the national and county road network, as well as payouts from insurance companies.[16]

In July 2011, violent torrential rain in Copenhagen resulted in major flooding and damage in the order of NOK 6 billion. In 2012, Storm Frida struck places such as Nedre Eiker in Buskerud county, which saw an unofficial precipitation record of 150 mm in the space of a few hours.

In 1789, the greatest ever known flooding in Norwegian history occurred. Public statistics show that the flooding cost the lives of 72 people, and that more than 1,500 farms were damaged. In 1995, parts of the interior of Eastern Norway were affected by flooding on virtually the same scale. 7,000 people were evacuated and one person was killed. Approximately 6,900 injuries were reported. It is estimated that the flooding caused damage valued at around NOK 1.8 billion.

Heavy snowfall can also create problems. Over four winter weeks in January and February 2018, large parts of inner Agder were without power supply for shorter or longer periods when heavy snowfall caused trees to bend over the power lines.

[12] *https://www.finansnorge.no/aktuelt/nyheter/2016/01/stormen-tor-har-herjet-i-mange-fylker/*
[13] *Norwegian Water Resources and Energy Directorate (NVE) (2012): Første inntrykk etter ekstremværet Dagmar, julen 2011 [First Impressions after Extreme Weather Event Dagmar, Christmas 2011], NVE Report 3/2012.*
[14] *Norwegian Post and Telecommunications Authority (PT) (2012): Foreløpige erfaringer og forslag til tiltak etter ekstremværet Dagmar [Preliminary experience and proposed measures after extreme weather event Dagmar], PT report no. 2 2012.*
[15] *METinfo No. 14/18 Extreme Weather Report Event: Cora, January 2018.*
[16] *NIFS Report 93/2015 "Samfunnsøkonomiske kostnader av Gudbrandsdalsflommen 2013", Christoph E. Siedler*

At one point, 24,000 customers were without power, and more than 6,000 subscribers applied for compensation because the power outage lasted more than 12 hours.[17]

The summer of 2018 broke temperature records and was very dry, providing a reminder that a lack of rain is also a risk for which society must be prepared. May was the warmest month in Norway on record and July was the second driest month since 1900.[18] Among other things, the drought resulted in shortages of fodder in agriculture and less replenishment of water reservoirs causing higher electricity prices.[19]

Risk

Storms and hurricanes
Strong winds of storm strength with the associated gusts (gust factor 1.2–1.5)[20] are the types of extreme weather that most often cause substantial damage in Norway, especially in combination with storm surges caused by water levels rising because of strong wind and low air pressure.

Climate models show little or no change in average wind conditions in Norway up to the year 2100.[21] At the same time, however, in the decades to come the likelihood of powerful storms and hurricanes will tend to increase, even in areas that previously not have been affected by this type of extreme weather, such as the Oslo Fjord region. Strong winds may also occur from unusual directions.[22]

Damage to buildings as a consequence of wind and flying objects are typical consequences of extreme wind conditions. The electricity supply is also vulnerable to storms, and trees falling on power lines is a particular problem. A number of infrastructure elements and societal functions are dependent on the continuous supply of electricity, and loss of power will, in itself, entail extremely large challenges for the community. In cases in which storms and hurricanes bring with them large volumes of precipitation, this may also involve problems for water and sewerage systems.

Flooding and precipitation
A review of the events over the last two hundred years shows that there have been 40-60 major floods in Norway. This means that flooding with major consequences occurs relatively frequently somewhere in Norway.

Climate change is expected to result in fewer and smaller snowmelt floods, but more frequent and severe flash flooding in Norway in the period up until 2100. From 1900 to the present day, average precipitation has increased by around 18% across the country (average annual precipitation in mm/year), with the biggest increase coming since 1980. As far as heavy precipitation over a short space of time (less than 12 hours) is concerned, there has been an increase in both intensity and frequency in recent years. This means that more periods of heavy local precipitation can be expected in the future.[23]

Heavy rain can overwhelm the pipe systems designed to collect storm water in densely populated areas causing flooding when the water has to find new routes above ground. A higher frequency of periods of high-intensity precipitation will also increase the likelihood of earth and mud slides, including in areas that have not previously been prone to such events.

The material damage caused by flooding can be very serious. Masses of water flooding and raging buildings, bridges, roads and agricultural land can inflict huge economic losses. Water supply and sewarage infrastructure is also vulnerable to flooding. In addition, flooding may entail the need for evacuation, reduced navigability for the transport of freight and passengers as a consequence of destroyed infrastructure and reduced provision of public services.

The historical record contains a series of reports on the loss of human lives in flooding and other watercourse accidents. In more recent times, however, there have been few fatalities in Norway as a consequence of flooding, due to improved warning and communication systems. However, warning of, and preparing for, flash flooding due to torrential rain is a major challenge because it is harder to calculate precisely where the torrential rain will fall. The risk of loss of life is therefore greater in the case of such events.

[17] *Fædrelandsvennen May 8 2018.*
[18] *METinfo no. 07/2018 Været i Norge Klimatologisk månedsoversikt. Juli 2018.*
[19] *https://www.nve.no/nytt-fra-nve/rapporter-kraftsituasjonen/kraftsituasjonen-veke-29–2018/*
[20] *With a given average wind strength, there is normally a gust factor of 1.2-1.5. In other words, with a full storm of 25 m/s, one can expect gusts of 30-37.5 m/s under normal conditions. In some circumstances the gust factor can be higher. Hurricanes normally result in unusually widespread damage. Full storms with gusts of more than 32.7 m/s do not. (The Norwegian Meteorological Institute).*
[21] *NCCS report no. 2/2015 Climate in Norway 2100.*
[22] *Haugen and Iversen (2008): Response in extremes of daily precipitation and wind. Meteorologisk institutt.*
[23] *NCCS report no.2/2015 Klima i Norge 2100.*

Prevention and emergency preparedness

The effects of climate changes depend on how we prepare to meet them. More robust infrastructure and the establishment of early warning systems are important measures for adaptation.

Each sector and each level of administration have independent responsibility for reducing the impact of climate change within their specific area of responsibility. The responsibility for climatic adaptation rests with the public sector, business and private individuals. To reduce the impact, it is important both to have preventive measures, via land-use planning, for example, and a contingency system for managing the situation when it arises.

Norway's Planning and Building Act with associated regulations and the Civil Protection Act[24] with the specifications in the regulations relating to the emergency preparedness duties of municipalities, are crucial to ensuring necessary climate adaptations. For example, the Planning and Building Act specifies requirements for assessing natural damage in all construction activity in Norway.

The Norwegian Ministry of Petroleum and Energy has the overall responsibility for preventing flooding and landslides while the operational responsibility has been delegated to the Norwegian Water Resources and Energy Directorate (NVE). This responsibility involves providing assistance in the form of know-how and resources for mapping, land-use planning, protection, monitoring and warning as well as assistance during events. The Norwegian Water Resources and Energy Directorate (NVE) is responsible for the national flood alert service and mans a 24-hour emergency preparedness call center.

After the New Year hurricane in the Møre og Romsdal region in 1992, a national plan was established for providing warnings of extreme weather events. The Meteorological Institute is responsible for the contingency plan, which must ensure that different bodies are prepared and able, to the highest possible degree, to maintain vital societal functions. The warning is issued to the NVE and the Maritime Rescue Coordination Centre in and, the county governor in affected areas (Governor of Svalbard if Svalbard is affected), and then forwarded to other emergency response authorities both at a national, regional and local level.

Since May 2018, the MET has graded its warnings using a colour scale, yellow, orange and red, where a red alert is issued when an extreme weather event is expected. The warnings conform to the format of the Common Alerting Protocol (CAP), which is an international standard. In addition to the extreme weather alert, CAP messages contain information about the hazard and likelihood of an event occurring. In order to facilitate the understanding of the alerts the CAP messages even contain information on the potensial effects of the expected weather and a more accurate designation of the areas the warning applies to.

The MET's alerts also differentiate between 'torrential rain' and 'rain' since this has a big impact on the uncertainty of the forecasts and the associated challenges presented by the damage.[25] In emergency flood situations, several emergency response authorities will be involved and have responsibilities, including municipal authorities, the police, the Maritime Rescue Coordination Centre, the Norwegian Civil Defence, the Norwegian Public Roads Administration, Bane Nor and County Governors.

	Colour	Response	Type of situation	Designation
	Yellow	Be aware	Challenging	Yellow level
	Orange	Be prepared	Severe	Orange level
	Red	Take action	Extreme	Red level

TABLE 2. The MET's risk warnings.

Source: https://www.met.no/vaer-og-klima/ekstremvaervarsler-og-andre-farevarsler/faregradering-i-farger

[24] *Act of 25 June 2010: Act relating to Municipal Emergency Preparedness, Civil Protection and the Norwegian Civil Defence (the Civil Protection Act).*
[25] *https://www.met.no/vaer-og-klima/ekstremvaervarsler-og-andre-farevarsler/vaerfenomener-som-kan-gi-farevarsel-fra-met/farevarsel-for-nedbor*

STORM "VIDAR" IN 2017:
High water level in the Vågen inlet in the centre of Stavanger during Storm Vidar in 2017.

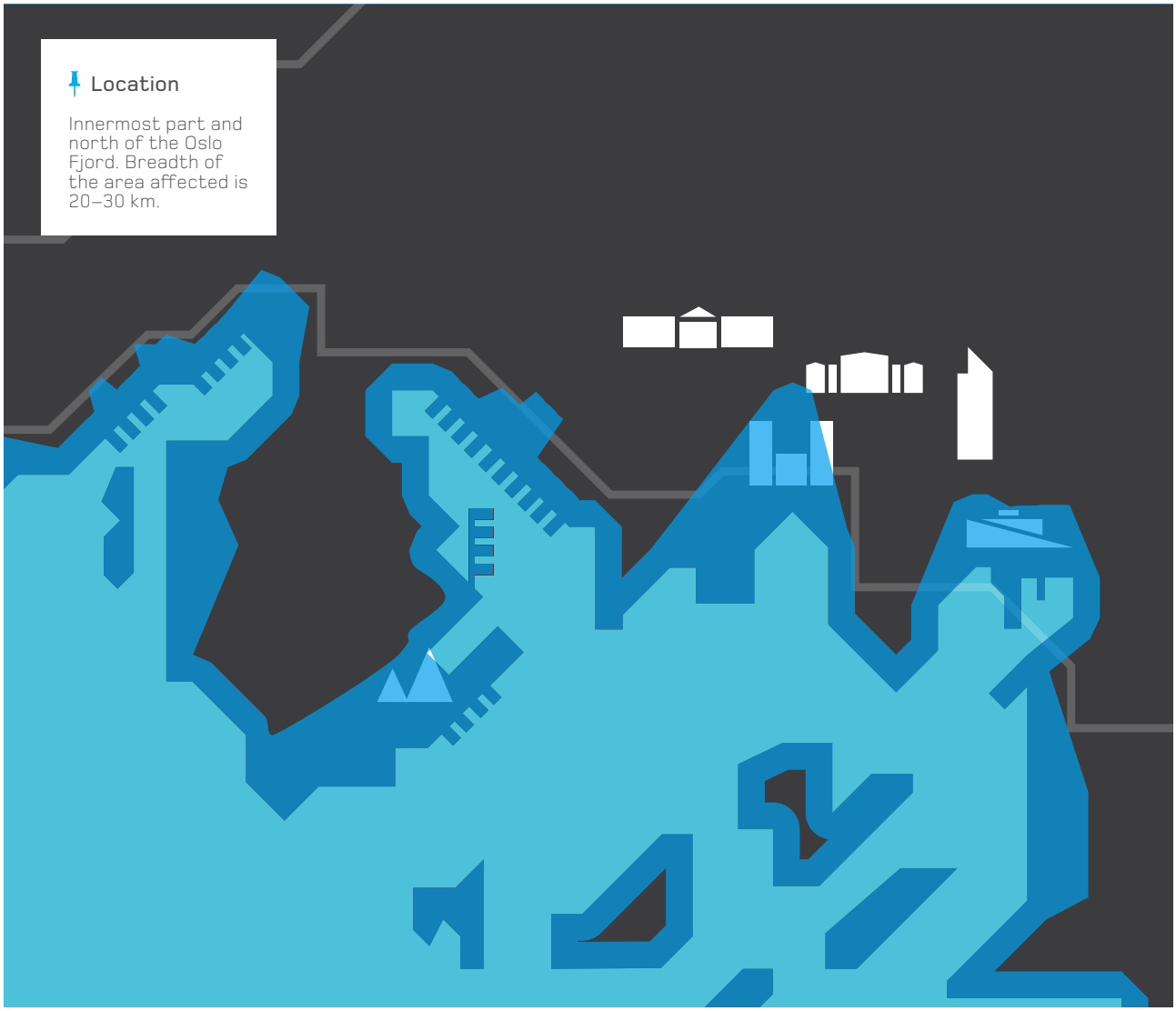
PHOTO JON INGEMUNDSEN / STAVANGER AFTENBLAD

SCENARIO

03.1 Storm in Inner Oslo Fjord

Powerful storms with hurricane-strength gusts can cause major damage in built-up areas. Strong winds do more damage in southeastern Norway than they do in other parts of the country due to factors such as the higher number of buildings, more extensive infrastructure, and forest suited to lower wind speeds. A risk analysis of a serious scenario was conducted in 2010 to shed light on the consequences of a powerful storm in the southeastern Norway region. The risk analysis was updated in 2018.

Course of events		
In the middle of the night, wind speed increases to storm force with gusts of more than 34 m/s in inner Oslo Fjord. It has rained a lot in the last 24 hours (30–60 mm) and there is already moderate flooding in a number of smaller watercourses. The temperature is 5°C and falling. The storm coincides with a spring tide, and the wind pushes water up the Oslo Fjord, and leads to a storm surge of 250 cm in inner Oslo Fjord. The storm causes extensive damage to the electricity grid and drinking water contamination in some places, due to storm water and inadequate purification.		
Time	**Scope**	**Similar events**
16 hours, one 24-hour period in October (starting at 0300 hours)	Average wind speed of 19 m/s with gusts of 34 m/s. Temperature of 5 °C during the storm, period of cold weather afterwards.	Storm Gudrun in 2005, 18 fatalities in Sweden.



Assessment of vulnerability

The power supply system in Oslo has a high level of built-in redundancy and robust infrastructure. The supply comes from different main directions and is carried by a central distribution network designed to withstand extreme weather. Much of the distribution network in Oslo city centre, at all voltage levels, is underground, making it very robust as far as the elements are concerned. Oslo's location means it is also relatively sheltered from storms, more so than those parts of Sweden struck by Storm Gudrun.

However, less of the distribution network outside the capital consists of underground cables and it is therefore more vulnerable to storms of this kind. A strong storm could, therefore, cause major damage to society, although it is difficult to imagine that power supplies to Oslo would experience prolonged, extensive outages.

In the event of a power outage, electronic communications services such as the Internet and mobile phone networks would become unavailable relatively quickly, depending on battery capacity and any backup generator solutions. Water treatment plants will also have to rely on backup power to purify drinking water.

When areas are hard to get to rescue work is challenging. High numbers of fallen trees close roads, which makes it difficult for emergency vehicles to reach sites. Cleaning up after a storm is also difficult and requires good cooperation between the authorities and emergency services. People with the skills necessary to remediate storm damage may also be scarce.

A milder climate with more precipitation and the absence of frozen ground in the winter will reduce the ability of trees to withstand storms.

Assessment of likelihood

The whole scenario, including heavy precipitation and a spring tide, is expected to occur once in a 100-year period. This results in an annual likelihood of 1 per cent and approximately a 65 per cent likelihood of the event occurring in a 100-year period. In Analyses of Crisis Scenarios, this places the scenario in the *moderate* likelihood category. The wind speed alone has an annual likelihood of 2 per cent, which results in a high likelihood (85 per cent) of this occurring in a 100-year value. This is generally referred to as a 50-year return value. The wind speed will often coincide with heavy precipitation, but rarely with a strong spring tide.

Meteorological data over a long period of time provides a good base of knowledge for specifying likelihood. Since this storm coincided with a storm surge and hit an area that are not often exposed to storms, there is, however, little experience with such strong winds here. The base of knowledge for specifying the likelihood of the specific scenario is assessed as average. The likelihood estimate is sensitive in relation to the assumption of a storm surge. Based on the knowledge base and the sensitivity, the uncertainty of the estimate is assessed as moderate.

Other parts of the country are considerably more exposed to strong winds. This means that if a 50-year return value storm occurs in some other part of the country, the storm will be much more powerful. For example, a 50-year return value is 19 m/s in inner Oslo Fjord and 26 m/s at Flesland in Bergen. The likelihood of the entire scenario with the wind, precipitation and spring tide occurring elsewhere in the country has not been considered.

Assessment of consequences

The consequences of the given scenario are assessed overall as *medium*. The scenario will primarily threaten the societal assets life and health and economy. In addition, the scenario will lead to social and psychological reactions, as well as long-term damage to the affected natural environment.

Life and health

The number of fatalities expected is around 15-20. This number is on a par with the number killed by Storm Gudrun in Sweden in 2005. Seven people were killed during the night of the storm and eleven during the demanding, risky cleanup work.[26] In the event of a storm in inner Oslo Fjord, there could be more fatalities as a direct consequence of the strong wind because the area is more densely populated. However, fewer would die in the course of the cleanup work because a smaller area of forest would be affected. Fatalities, injuries and illnesses will though occur due to transport accidents (damaged infrastructure), reduced navigability, failure of communications systems and in some places contamination of the number ofpersons suffering from injuries or illnesses as a direct or indirect consequence of the storm is assumed to be between 75 and 150.

[26] *Up to and including January 2016 (one year after the event), 11 fatalities were recorded in connection with the clean-up work in the aftermath of Storm Gudrun. 141 occupational injuries were also registered in 2005 in connection with the clean-up work. Source: MSB https://www.msb.se/sv/Om-MSB/Nyheter-och-press/Nyheter/Nyhetsarkiv/Nyhetsarkiv-2015/Tio-ar-sedan-stormen-Gudrun/*

The consequences for Life and Health have been assessed as small to moderate.

Nature and culture

It is assumed that damage to forests in parts of the storm-ravaged area will be extensive, but not irreparable. An estimated 1,000 km² of forest will be damaged, and the cleanup will take from three to ten years. One result of such a storm event is that insect pests could reproduce in such numbers that they would attack and kill off healthy forest.

The consequences for the natural environment have been assessed as moderate. The consequences for cultural environment have not been assessed.

Economy

It is estimated that the direct economic losses would be large and in the range of NOK 2–10 billion. This primarily represents repair and rebuilding costs associated with damaged buildings and infrastructure, such as roads, power supply, and water and sewerage systems. In addition to this, there would be significant, indirect production losses due to damaged industrial and commercial buildings, delay costs caused by due to the damages caused by the storm on the road network, sporadic power and electronic communications outages, etc.

The forestry industry would experience direct losses from the destruction of forests not ready for felling, value reduction[27] and additional costs from clearing trees knocked down by the wind in potentially dangerous and difficult areas. Transporting the timber would put an extra strain on forest roads and other local roads. Indirect economic losses would also be experienced in subsequent years in the form of changed operations in the forest, i.e. clearing and planting instead of felling timber, and dealing with any outbreaks of insect pests. It is estimated that the indirect economic losses would amount to NOK 2–10 billion.

Both the direct and indirect economic losses would be large.

Societal stability

Since a serious storm in this part of the country would have occured unexpectedly, few people would be prepared for the serious consequences the event would entail. Nonetheless, the storm scenario is not expected to produce any significant social and psychological reactions among the public outside the affected area. The fact that a storm cannot simply be avoided can, however, produce feelings of discomfort and apprehension, especially for those who experience serious losses.

Extensive local damages to critical infrastructures such as power lines, roads and water and sewerage facilities will effect people for a short period of time. It is assumed that the least damage will be in Oslo itself, due, for example, to a robust power supply infrastructure with underground electricity cables.

Due to damages to power lines, it is assumed that approximately 300,000 households are affected by the loss of power and will have no telephone or data communication for 1–7 days. While the power supply to Oslo is regarded as robust and able to withstand a storm of this strength, less of the distribution network outside the capital consists of underground cables and it is therefore more vulnerable to storms of this kind. Power outages present challenges for health and care services, problems in heating homes and buildings, as well as in the contamination of drinking water. Between 1,000–10,000 people would experience poorer water quality for about a week due to storm water and inadequate drinking water purification due to power outages. It is not assumed that evacuation will be necessary.

The consequences in the form of social and psychological response would be small. The stress on daily life would be large.

[27] *The fall in value for landowners would come from wind damage making it impossible to cut the timber to the most profitable lengths, deterioration in the quality of timber on the lying on the ground for some time, and it requiring more work to extract the timber.*

Assessment of uncertainty

The knowledge base for estimating likelihoods in this specific scenario is regarded as moderate. The estimated likelihoods are sensitive when it comes to the spring tide assumption. Given the knowledge base and sensitivity, the uncertainty of the likelihood estimate is regarded as moderate.

The uncertainty related to the various consequence types varies from little to great. The range of the potential number of fatalities is broad since the consequences of several simultaneous events and consequential events are involved. The number of people suffering serious injuries and illness would primarily depend on the duration of the power outage and to the extent to which the storm surge contaminates drinking water. The uncertainty related to the societal asset Life and Health is therefore regarded as moderate. There is a good knowledge base on consequences for the natural environment, and the uncertainty of the assessment is therefore regarded as little. The knowledge is based on experience from similar storms. The uncertainty associated with the consequences for Economy and Societal Stability is regarded as moderate.

Overall, the assesments of likelihood and consequences have *moderate* uncertainty.

Possible measures

- Consider closer cooperation between the MET and the emergency preparedness actors concerning crisis management.
- Further develop impact-based warnings, which were introduced as part of the new warning procedures.
- Increase competence on measures aimed at preventing storm damage in forestry.
- Underground cables should be used in the elctricity grid when conditions indicate that this could be done with only moderate intervention in the environment and only moderate increase in cost.[28]

[28] *The NVE's standard terms and conditions for area concessions.*

TABLE 3. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario				◎			65% likelihood of the event occurring in a 100-year period.
Similar events on a national basis							Not assessed.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MODERATE**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities		◎				15–20 fatalities during the event or in connection with the subsequent restoration work.
	People affected by serious injuries and illness			◎			75–150 serious injuries and illness
Nature and culture	Long-term damage to the natural environment			◎			1,000 km² of forest is destroyed 3–10 years of clean-up work.
	Irreparable damage to the cultural environment						Not assessed.
Economy	Direct economic losses				◎		NOK 2–10 billion in repair and reconstruction costs.
	Indirect economic losses				◎		NOK 2–10 billion in lost production, delay costs, and restructuring forestry operations.
Societal stability	Social and psychological response		◎				Known phenomenon, but difficult to avoid.
	Stress on daily life				◎		Several hundred thousand are affected by the lack of power and clean water for a few days. Reduced navigability for all means of transport.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES				◎			Medium-sized consequences overall.
Overall assessment of uncertainty							
		VERY LITTLE	**LITTLE**	**MODERATE**	**GREAT**	**VERY GREAT**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed as *moderate*.

SCENARIO

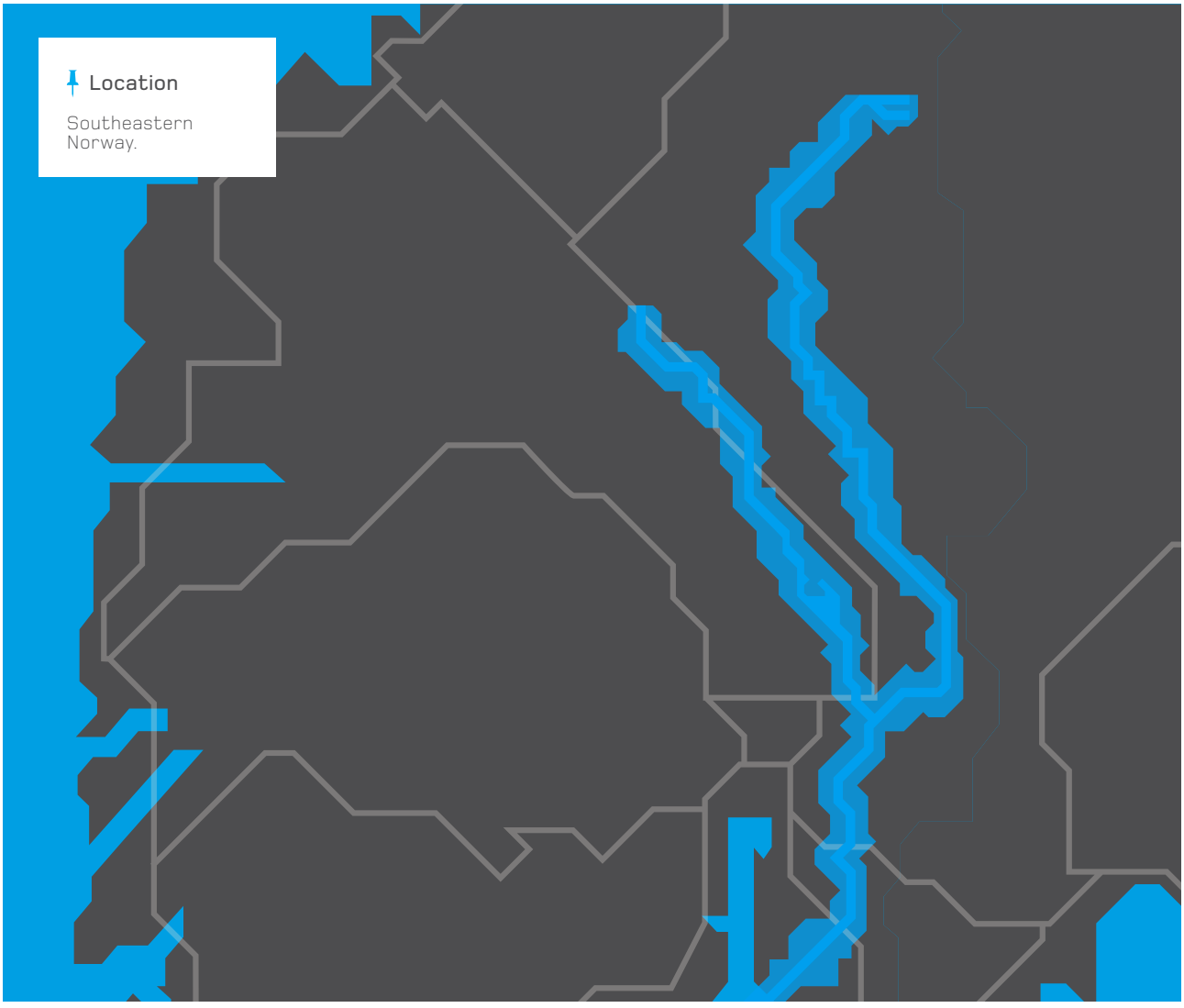
03.2 Flooding in Lågen and Glomma

Major flooding in watercourses in densely populated areas can have serious consequences for property and people's lives and health. The concrete scenario in this analysis is a situation in which melting snow and heavy precipitation result in massive water flow and flooding in the largest rivers in southeastern Norway. The risk analysis was conducted in 2011/2012 and updated in 2018.

Course of events

A winter of heavy snowfalls in southeastern Norway is followed by a cool spring with delayed snowmelt. At the end of May, a warm air front from the southeast moves over southeastern Norway, resulting in heavy snowmelt in the mountains throughout the region. The warm front also brings with it three days of heavy precipitation, which is of extremely high intensity in places. The combination of meltwater and heavy precipitation results in flooding in both Gudbrandsdalen and Østerdalen valleys, which in turn results in major flooding in Lake Mjøsa and Lake Øyeren. Tributaries also flood and streams form where water usually does not flow. Hundreds of landslides occur in the most susceptible valleys, one of which strikes densely populated areas.

Time	Scope	Similar events
Three days in May with an extreme amount of precipitation. An abnormally high rate of water flow for four weeks.	• 150–200 mm of precipitation in three days. Rate of water flow: • 3,500–5,000 m³ per second	• Floodings in the same area in 1789 and 1995.



Assessment of vulnerability

There are many ways of reducing vulnerability to flood events. The NVE draws up flood zone maps and assists and advises municipalities on how they should survey and take account of flood and landslide risks in land-use plans. The NVE can assist municipalities with protective measures aimed at mitigating risk to existing buildings vulnerable to flooding and landslides. New, improved warning services better enable the responsible authorities to implement urgent preventive measures such as deploying sandbags, flood barriers and temporary flood earthworks.

Norway has been struck by a number of smaller floods in recent years, and many municipalities in flood-prone areas have experience of dealing with flood events. The scope of this scenario, together with the power and electronic communications outages, would however, challenge and at times limit the ability of the authorities to perform its tasks.

Several vital societal functions would be impacted by such an event:

- Landslides and flooding would damage the supply networks and result in power and electronic communications outages.
- Damaged roads would prevent access for, among others, the emergency services, and important roads would be closed for a long time for repairs.
- Depending on the duration of the outage, power and electronic communications outages can result in health care safety alarms and medical devices ceasing to function.

Assessment of likelihood

As extensive flooding as the one outlined in the scenario in the rivers Glomma and Lågen requires a rare coincidence of several meteorological conditions, such as a strong and relatively stationary warm front moving along an unusual path from the south-east, as well as a lot of cold weather and snow earlier on that results in a late and rapid snowmelt. Such a coincidence can be expected to occur every 500–1,000 years, i.e. there is a 0.1–0.2 per cent likelihood that the event will occur in the course of a year, and a 15 per cent likelihood of the event occurring in a 100-year period. In Analyses of Crisis Scenarios this ends up as *low* likelihood.

Rare and extremely serious flooding events like this can probably occur in four to six regions in Norway. Assuming this, the likelihood of such a scenario somewhere in Norway in a 100-year period is 55 per cent, i.e. there is *moderate* likelihood.

The likelihood estimate is based on prior flooding in Norway and Northern Europe from historic times. Climate change is expected to result in more precipitation and higher temperatures. The uncertainty associated with the likelihood estimate is assessed as moderate.

Assessment of consequences

There are approximately 20,000 people living in the areas that will be directly affected by the flooding in the scenario. Overall the societal consequences are assessed as *medium*. The scenario will primarily threaten the societal assets Life and health and Economy. In addition, the scenario will entail major damage to critical infrastructure and result in some unrest in population.

Life and health

At least 10 human lives are assumed to perish due to the many avalanches that will occur and tributaries carrying a lot of materials that forge new routes. There is also the risk of a considerable loss of life if the areas on the inside of the large flood barriers (primarily along the Glomma River) are not evacuated in time. We have assumed that there is sufficient time to provide advance warning of the flooding and that the areas are evacuated before any flood defences are overtopped. It is assumed that between 100 and 300 people will be injured or become ill as a direct or indirect consequence of the major flood.

The consequences for Life and Health have been assessed as small to medium.

Nature and culture

The water will carry away the soil and cultivated land will be eroded and remain under water for a period of time. Both nature reserves and cultural assets will be affected, but it has been assessed that the flooding will not entail long-term serious damage to the natural or cultural environment. Even if large areas are flooded, this will not have lasting negative consequences for the environment.

The consequences for the natural environment and the cultural environment have been assessed very small.

Economy

Direct economic losses are estimated to range from NOK 5 to 10 billion. This is attributed primarily to damage to infrastructure and buildings, which will be costly to repair and rebuild. It is estimated that the indirect economic losses, such as temporarily lost production in affected areas, would amount to NOK 5–10 billion.

Both the direct and indirect economic losses are regarded as large.

Societal stability

Major flooding on the scale assumed in the scenario would result in some anxiety among the public. Even though flooding is a known natural phenomenon, the severity, with the loss of life and helplessness in the face of natural forces, would affect many people and create fear and uncertainty among the public.

People who live in the flood-threatened areas will be warned and have an opportunity to escape. Housing and real estate, however, are very vulnerable to damage. Flooding will affect schools, day care centres and institutions in the area, either directly or indirectly, when the transport system collapses.

People will expect that the authorities are prepared to deal with the event since flooding is a known phenomenon and a warning can be given. There may also be a lack of emergency response personnel to secure buildings, rescue animals from farms, etc., while the flooding is ongoing. Rescue work will be difficult because of inadequate navigability (large amounts of water and damaged roads).

Almost all of the 20,000 people who live in the area subject to flooding will be evacuated from a few days up to a month. Almost all of the households will experience problems with the supply of water from the waterworks and electronic communications. There will be a great deal of damage to the roads and railways in the area, and this will affect both local and through-going traffic. It is also assumed that most of the households in the area will lose power for a short period of time (3 to 7 days).

The social and psychological response has been assessed as small, but the stress on daily life has been assessed as large.

Assessment of uncertainty

There is little uncertainty attached to the knowledge base for the risk analysis of flooding, and the event is well understood. The key precondition in the assessment of likelihood is the weather situation. The outcome of the flooding is associated with rapid snowmelt coinciding with the precipitation, although lesser flooding could also inflict extensive damage. The sensitivity of the results has therefore been assessed as *medium*.

The uncertainty of the assessment of the consequences is regarded as medium to small. The consequences, especially for Life and Health, heavily depend on where a landslide strikes, and whether flood defences are breached before an evacuation has been completed. The uncertainty associated with the consequences for the natural environment and economic losses is regarded as small given the assumptions on which the scenario is based.

Overall, the uncertainty of the estimates of likelihood and consequences is regarded as *small*.

Possible measures

- Municipalities must have updated and practised emergency response plans that include evacuation and using equipment such as temporary installations (sandbags, plastic barriers, aluminium walls, etc.).
- It is important that municipalities monitor flood alerts, including using the subscription service for flood risk alerts from www.varsom.no.
- Municipalities must ensure that land use in flood-prone areas is restrictive.
- There is a model for water level alerts from Elverum to Lake Øyeren. A similar model should be established for several stretches of the Glomma/Lågen river system. ◎

TABLE 4. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario			◎				15% likelihood of it occurring in a 100-year period.
Similar events on a national basis				◎			55% likelihood of a similar scenario occurring in a 100-year period on a nationwide basis.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities		◎				10–20 fatalities as a direct or indirect consequence of the event.
	People affected by serious injuries and illness			◎			100–300 affected by injuries and illness.
Nature and culture	Long-term damage to the natural environment	◎					The flooding causes insignificant damage to the natural environment.
	Irreparable damage to the cultural environment	◎					The flooding causes insignificant damage to the cultural environment.
Economy	Direct economic losses				◎		NOK 5–10 billion due to damage to infrastructure and buildings.
	Indirect economic losses				◎		NOK 5–10 billion due to temporarily loss of production.
Societal stability	Social and psychological response		◎				Anxiety among the public due to, among other things, the loss of life.
	Stress on daily life				◎		A high number of people evacuated and power, electronic communications, and water outages.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES				◎			The societal consequences have been assessed as medium.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY			◎				

SCENARIO

03.3 Flash Flooding in a City

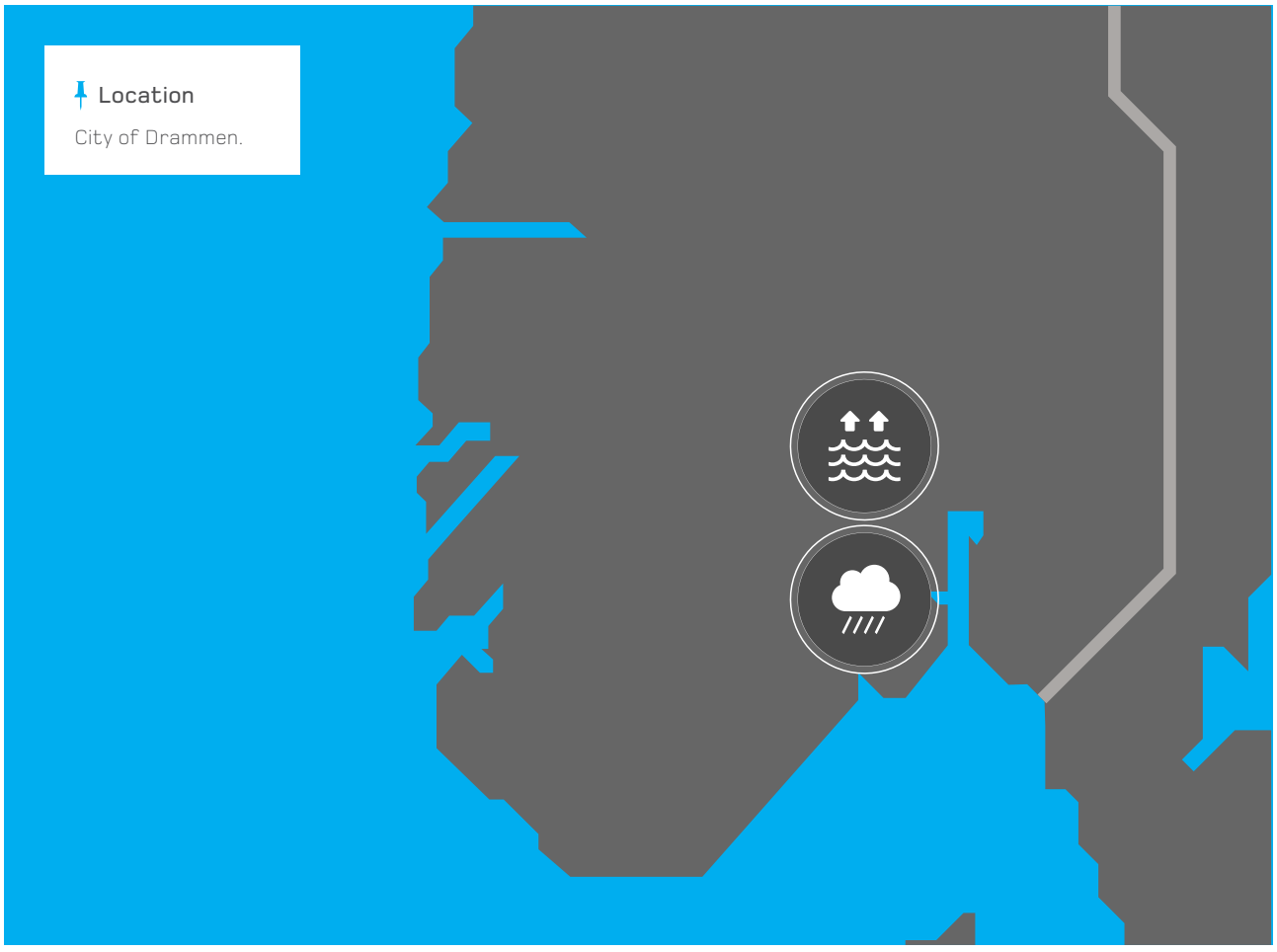
Torrential downpours can quickly cause major flood damage in densely populated areas. Areas with paved surfaces, a high density of buildings and streams that have been diverted into pipes are especially vulnerable. In autumn 2016, a risk analysis was conducted for a specific scenario involving flash flooding in the city of Drammen. The analysis was documented in a separate report.[29]

Course of events

After a prolonged period of heavy rain and high temperatures, a deep low pressure system with frontal precipitation is on its way into the Oslo Fjord. The MET has issued a 'Be aware' alert concerning the risk of heavy precipitation in some areas, but is uncertain where the precipitation will fall. In Drammen, thousands of people are gathered in the city centre's streets for the annual river festival. The torrential rain starts with a powerful thunderstorm. Power is knocked out and, in the dark, chaos and distress break out in the crowd.

After half an hour, the storm water system and the tributaries diverted through pipes on the hillsides are overwhelmed. Water soon floods through the city and there are several landslides on the hillsides and along the river. At the same time, the water level in Drammen Fjord rises because of a storm surge and low-lying areas along the Drammen River are flooded.

Time	Scope	Similar events
A Sunday evening in August. Clean-up work for several weeks/months.	110 mm of torrential rain in two hours cause flash flooding in the city centre.	• Torrential rain in Copenhagen on 2 July 2011, 135 mm of precipitation in 2.5 hours. • Storm Frida on 6 August 2012, 150 mm in a few hours in Nedre Eiker municipality.



[29] *Report "Risikoanalyse av regnflom i by", DSB, 2016.*

Assessment of vulnerability

Urban areas with impermeable, asphalted and built on surfaces have little extra capacity to absorb storm water when their water and wastewater systems are under pressure. In Drammen, all of the 50 or so streams that run down the hillsides have been diverted into pipes, and these have limited capacity when it comes to accommodating large new volumes of precipitation. Steep hillsides and areas of quick clay along the river make the city extra vulnerable to landslides and quick clay slides caused by flooding.

Accurate warning of torrential rain has proved a challenge and has made it difficult for local authorities to adequately prepare for this type of flood events. However, new measuring methods for recording minute precipitation in combination with weather radar have helped to improve warnings of short-term precipitation in the last few years. In 2018, the MET also introduced new risk alerts that differentiate between torrential rain and other forms of rain. This makes it easier for the authorities to implement measures both before and during the event.

The impact of the event on vital societal functions is assessed in a vulnerability analysis presented in the sub-report. Transport capacity is squeezed when both main roads and diversions are closed due to flooding and landslides. Sporadic power and electronic communications outages and a damaged road network also limit the ability of local and regional crisis management teams and the emergency services to perform their primary functions.

Assessment of likelihood

The likelihood of the flash flooding scenario occurring in Drammen is regarded as relatively *high*, i.e. approximately 75 per cent likelihood in a 100-year period[30] (1-2 per cent annual likelihood).

The assessment is based on statistical return periods for short, torrential downpours in the Oslo Fjord area and a 'climate factor' that takes into account 40 per cent increase in extreme precipitation in the period up to 2050. Without the climate factor, the likelihood would be somewhat lower. Extremely heavy rain showers often last for less than two hours. Therefore, the likelihood of a lot of precipitation falling per minute is higher for shorter downpours than for longer downpours, even though the overall amount of water is the same. Based on these assumptions, the likelihood that 110 mm of precipitation could fall in two hours is high.

Torrential rain will certainly result in flooding in the streams on the hillsides in Drammen with subsequent large or small landslides. Extreme rain showers can naturally coincide with strong winds from the south that push the water up the Drammen Fjord, producing a storm surge and high water level in the lower reaches of the Drammen River. The likelihood of flash flooding occurring in one of the 20 vulnerable towns and cities along the Oslo Fjord and Skagerak is very close to 100 per cent, i.e. *very high*, in a 100-year period.

Assessment of consequences

The overall consequences of the given scenario are regarded as *small* compared with other crisis scenarios, although the scenario would nonetheless threaten the societal assets Life and Health, Nature and Culture, Economy, and Societal Stability.

Life and health

It is estimated that there would be a total of six fatalities and 50–60 would be injured or become ill, mainly due to landslides, lightning strikes and road traffic accidents. The Bragernes Tunnel in the city centre fills with water and people start to evacuate the tunnel on foot, at the same time as more vehicles are entering it. One person is run over and killed in the tunnel.

A landslide caused by flooding is triggered in Strømsåsen hillside where five houses are struck, with two houses being completely destroyed. Two people are killed in the landslide. Subsequent erosion in streams near the Drammen River triggers minor quick clay landslides without warning. Approximately 20 people are expected to fall ill with gastric catarrh due to contaminated drinking water following the event. Rescue work is delayed due to partially impassable roads and this contributes to the scope of the damage.

The consequences for Life and health have been assessed as small.

Nature and culture

It is estimated that the scenario will result in long-term damage to the natural environment. The damage to the environment would be limited to the areas where the landslides occur and nearby areas that are affected by loose masses. Forest, cultivated land, and wilderness would be minimally affected. Cultural assets with a high conservation value in the centre of Drammen would be threatened by flooding from Drammen River and tributaries. Irreparable damage may therefore be sustained by buildings and the cultural environment, but the scope is uncertain.

[30] *We assessed the likelihood of the scenario occurring in a 50-year period in the subreport "Risikoanalyse av regnflom i by". This resulted in a moderate likelihood (40-60%).*

In this scenario, the consequences for the natural environment have been assessed as very small and the consequences for cultural assets have been assessed as medium.

Economy

The economic losses include both direct and indirect losses for private individuals and companies. The direct economic losses in this scenario is estimated at around NOK 500–750 million, primarily due to costs associated with reconstructing damaged roads and infrastructure, municipal properties and replacing lost furniture, fittings, and equipment.

In comparison, Storm Frida resulted in well over 1,000 claims and compensation payouts of NOK 424 million in Buskerud County.[31] The event in the scenario would not result in production disruptions in businesses in Drammen, so the indirect economic losses are limited, apart from some delay costs due to reduced road and possibly rail access.

The direct economic losses are regarded as medium, while the indirect economic losses are regarded as very small.

Societal stability

The public accepts that natural events occur, but sudden flooding and landslides would nonetheless be felt as frightening, both by those affected in Drammen and the rest of the public. The delayed efforts of the emergency services and a lack of information from the municipality would produce feelings of frustration and insecurity. The stress on daily life would be small and take the form of short-term power outages and unstable electronic communications services for up to five days after the event. Repairs of damaged roads would cause the need for local diversions, although most of the roads would reopen within a week. Residents in the landslide-prone areas would be evacuated, but most would return after a short period of time.

The social and psychological response of the public has been assessed as medium, while the stress on daily life has been assessed as small.

Assessment of uncertainty

There is a good knowledge base for the risk analysis of urban flash flooding, and this is partly based on experience from similar events elsewhere. There are good map data for landslide and flood-prone areas, streams, floodways and cultural heritage sites, as well as weather statistics and precipitation forecasts. We have a good understanding of the phenomenon and there was a large degree of concensus among the experts who took part in the risk analysis. Small changes in the precipitation volumes and duration would have little effect on the analysis results. Both landslides caused by flooding and quick clay landslides can occur in many cities around the Oslo Fjord. The crowds gathered in the city centre have an effect on the consequences, but only to a limited extent. Overall, the uncertainty of the analysis results has been assessed as *small*.

Possible measures

The analysis results point out several possible measures, including:

- More accurate warnings of extreme weather (time and place) from the MET, at least one hour prior to the event.
- It is important for emergency services and crisis management teams that the potential consequences a torrential rainfall can have for critical infrastructure and the public are recognised quickly.
- Extreme torrential rain should be included in comprehensive local and regional vulnerability analyses and emergency response plans.
- The 'Storm Water Committee' (2015)[32] suggested a number of changes to regulations and frameworks that will make it easier for municipalities to adapt to the problem of storm water.
- The Norwegian Public Roads Administration and the national railway infrastructure company, Bane NOR, in cooperation with the Norwegian Water Resources and Energy Directorate (NVE), have proposed a series of measures through the NIFS Programme[33] for how best to manage natural hazards through cooperation across agencies and areas of responsibility.

[31] *Report "Risk analysis of flash flooding in a city", DSB, 2016.*
[32] *The committee behind Official Norwegian Report (NOU) 2015:16 "Overvann i byer og tettsteder–som problem og ressurs" (2015).*
[33] *NIFS (Naturfare, Infrastruktur, Flom og Skred) [Natural hazards, infrastructure, flooding and landslides], see NIFS's final report 43/2016, among others.*

TABLE 5. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario					◎		The likelihood has been assessed as 75% in a 100-year period.
Similar events on a national basis						◎	The likelihood of this occurring in one of the 20 vulnerable towns and cities along the Oslo Fjord and Skagerak is very high (almost 100%).
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities		◎				An estimated six fatalities due to landslides, lightning strikes, and road traffic accidents.
	People affected by serious injuries and illness		◎				An estimated 55 people who are either injured due to landslides, lightning strikes, and road traffic accidents or fall ill due to, among other things, contaminated water.
Nature and culture	Long-term damage to the natural environment	◎					Little long-term damage to the environment.
	Irreparable damage to the cultural environment			◎			Individual protected objects and cultural environments worth preserving would be subjected to flooding and storm water.
Economy	Direct economic losses			◎			NOK 500–750 million in repair and replacement costs for buildings, roads and drains.
	Indirect economic losses	◎					Limited loss of earnings due to delay costs and reduced commerce.
Societal stability	Social and psycho-logical response			◎			Chaotic emergency phase with inadequate warnings, complex situation, difficult crisis management, little i nformation and delayed rescue efforts.
	Stress on daily life		◎				Power outages and unstable telecom-munications and data services for a few days and roads closed for days/weeks. 50 houses evacuated and six houses completely destroyed by landslides.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES			◎				Small consequences overall.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY			◎				Overall, the uncertainty has been assessed as *small*.

EXTENSIVE DAMAGE:
Wrecked houses after the quick clay landslide in Namsos 2009.

PHOTO: GORM KALLESTAD / NTB SCANPIX

04

LANDSLIDES AND AVALANCHES

Background

Various types of landslides and avalanches are differentiated by the nature of its movement and materials involved: rock, earth or snow. Landslides and avalanches are part of ongoing natural geological processes when rocks and loose materials are broken down. Analyses of Crisis Scenarios 2019 presents analyses of two types of landslide: a rockslide and a quick clay landslide.

Rockslides

Rockslides are defined as slides with a volume of over 100,000 m^3 of rock material. It can be difficult to identify rockslide triggers because deformations can develop over a long period of time. Increased water pressure, earthquakes tremors or frost action can trigger rockslides.

Rockslides are among the most serious natural disasters that can occur here in our country. Large rockslides are rare, but the degree of damage can be great. Historical evidence shows that there have been two to four fatal rockslide incidents every century in Norway. When a large rock slope collapses and slides out, it gains colossal power and range. If the material reaches a fjord or lake, flood waves may arise that can propagate over larger areas.

The last major rock landslide disasters in Norway occurred in the 1930s in Tafjord and Loen. During the landslide in Loen in 1905, 61 people were killed, while the 1936 slide in the same place led to the death of 73 people. The landslide in Tafjord, two years prior, the death toll was 40. Common to these landslides was large rock slopes collapsing and impacting into fjords, causing enormous flood waves that had a very wide range and a disastrous impact on people, buildings, animals and cultivated land.

TABLE 6. Classification of landslide and avalanche types in Norway (Source: NVE).

Hard rock	Loose material Coarse ◄——► Fine		Snow
Rockfall	Landslide		Avalanche
Rockslide Deep-seated landslide	Debris flow slide	Quick clay landslide	Wet snow avalanche

Quick clay landslides
Quick clay is associated with the last ice age and the isostatic uplift that follwed the ice retreat. Clay that was deposited in saltwater (marine clay) in front of glaciers has subsequently risen above sea level. Long term flows of freshwater running through the clay has washed out the salt. Today, quick clay is found as pockets or layers of marine deposits, right up to the marine level, which is the highest level the sea reached after the last ice age. The largest deposits of quick clay are found in Eastern Norway and in Trøndelag, where the marine level is highest, and we have the thickest layers of marine deposits. However, smaller quick clay deposits can be found in marine deposits along the entire coast of Norway.

What characterises quick clay landslides is that ruptures in the clay will often impact very large areas. This is due to quick clay landslides propagating backwards, forwards or sideways from where the clay was initially overloaded. The clay at the rupture point will almost liquify and the landslide mass can therefore cover a large area. The largest quick clay landslide incident occurred in Verdal in 1893 when 116 people perished. In 1978, one person was killed in a quick clay landslide in Rissa. 20 houses and three farms were destroyed by the landslide. In 2016, three construction workers died in a quick clay landslide in Sørum in connection with filling work.

Quick clay landslides can be triggered by natural processes such as river erosion, as was the case in Verdal. In modern times, human interventions are the commonest cause of clay overloading and landslides being triggered, although landslides triggered by erosion still occur. Small filling activities or excavation works can, under certain conditions, overload clay and trigger a landslide.

Risk

Landslides and avalanches are among the natural hazards that cause the greatest number of deaths in Norway. Since 1900, over 500 landslides and avalanches have been recorded, and 1,100 lives have been lost. Since 1900, snow avalanches have been responsible for most fatalities, followed by rockslides and quick clay landslides.

Landslides and avalanches are essentially natural processes that occur at irregular intervals. Human activity and encroachments into the terrain, however, affect the risk of slides. Snow avalanches can be triggered by skiers, and quick clay landslides can be triggered by excavation or filling work. Even if we try to avoid settlement and development in areas where there is a high likelihood of landslides and protect existing infrastructure and settlements, there is always a risk of adverse events.

Rockslides
The government rockslide survey programme maps unstable rock slopes in Norway. Unstable rock slopes in the counties of Troms, Møre og Romsdal, and Sogn og Fjordane, as well as parts of Telemark and Rogaland, are being mapped in detail. The purpose is to clarify the need to take special account of the risk of rockslides involving large, unstable rock slopes in land-use planning, as well as assessing the need for risk mitigation measures.

The Norwegian Water Resources and Energy Directorate (NVE) is responsible for surveying the risk of rockslides, and the Geological Survey of Norway (NGU) carries out the work on behalf of the NVE. A systematic overview mapping is being carried out to identify potentially unstable rock slopes. This is being done with the help of InSAR, aerial photographs and field surveys of geology and joint systems. A more detailed mapping is being conducted of rock slopes that constitute a potential rockslide hazard. In addition to measuring movement and volume of the unstable rock slope, the range and consequences of a potential rock slide is also mapped.

The survey work includes hazard and risk classification of rock slopes in which movement is measured over time, and where there is a risk to settlements. More detailed geological surveys are conducted for rock slopes classified as high risk in order to assess the need for risk mitigation measures. These will often entail round the clock monitoring and warning systems. Seven high-risk rock slopes (high-risk objects) have been identified.

For medium-risk rock slopes, periodic measurements of the movement of the rock mass are conducted in order to monitor how the rock mass is developing, and whether the risk is increasing or decreasing. Such periodic measurements are currently being made of 83 rock slopes. Further surveys are not conducted for low-risk rock slopes.

Four of the seven high-risk objects represent a risk of flood waves since any rockslide would fall into a fjord. Surge areas are therefore mapped based on the volume of the unstable mountainside and height of the flood waves washing ashore.

Quick clay landslides
The mapping of quick clay areas with a potentially high landslide risk started after the Rissa landslide in 1978. 2,000 quick clay zones with a potential risk of major quick clay landslides have now been mapped in Norway. The vast majority of these are in Eastern Norway and Trøndelag. All of the mapped zones have been assessed based on hazard degree (an expression of the likelihood of a landslide) and the impact of a landslide. Based on this, a risk classification system has been produced for the mapped zones, which is used as a tool for prioritising zones that require further investigation and possibly securing if there is a need. Around 140,000 people currently live in the mapped quick clay zones, and these also contain other buildings such as schools, kindergardens, and industrial and commercial buildings. Some areas that are potentially prone to a major quick clay landslide have still not been mapped.

TABLE 7. Distribution of mapped zones (quick clay) with regard to the degree of risk and risk classes (risk class 5 has the highest risk).

Risk class / Degree of risk	1	2	3	4	5
High degree of risk	10	34	118	48	18
Average degree of risk	113	302	538	115	7
Low degree of risk	122	318	340	21	1

Prevention and emergency preparedness

Individual inhabitants, landowners and owners of buildings and infrastructure have a responsibility for safeguarding themselves and their property. The municipalities have a general responsibility for safeguarding their inhabitants and local emergency preparedness, which also includes conducting risk and vulnerability analyses. The municipalities also have responsibility for land-use planning and are required to ensure that any new buildings are located in accordance with the safety requirements for floods, landslides and avalanches stipulated in Acts and Regulations. Developers are responsible on their side for studying hazards prior to any new development.

The Norwegian Ministry of Petroleum and Energy has the public administrative responsibility for floods, landslides and avalanches, with the Norwegian Water Resources and Energy Directorate (NVE) as the operative authority. The NVE assists municipalities and society in general with managing the challenges related to floods, landslides and avalanches through hazard mapping, follow-up of land-use plans, implementation of protection measures, monitoring and warning, as well as assistance during incidents.

Mapping, land-use planning and protection measures reduce the risk of damages as a consequence of flooding, landslides and avalanches. Nevertheless, it is not possible to eliminate all risk, and society must therefore make preparations for the occurrence of such events. The NVE is responsible for the national flood, landslide and avalanche warning service, which issues warnings at the regional level, while it is up to local actors to monitor the relevant valley mountainsides and debris avalanche channels. In emergency situations linked to flooding, landslides and avalanches, several emergency response authorities will be involved, including municipal authorities, the police, the Joint Rescue Coordination Centre, the Civil Defence, the Norwegian Public Roads Administration, the Norwegian National Rail Administration and the County Governor.

Large rockslides

Major, high-risk unstable rock slopes in Norway are monitored by the NVE. Seven areas have been identified as high-risk objects and are subject to round the clock monitoring/alerts with associated emergency preparedness. These are Åknes, Hegguraksla and Mannen in Møre og Romsdal, Joasetbergi in Sogn og Fjordane, Jettan, Indre Nordnes and Gámanjunni 3 in Troms. Several thousand persons may be directly affected if a rockslide occurs in these locations.

Quick clay landslide

Erosion in waterways is an important natural factor for triggering quick clay landslides. The risk of quick clay landslides can be reduced by implementing erosion protection or stability-improving measures. The NVE has implemented such preventive measures in cooperation with the municipalities and other public agencies, including the Norwegian Public Roads Administration, for a number of years. In addition, the NVE works actively with guidance and follow-up of land-use planning in the municipalities, with the intent of avoiding development in hazardous areas, or of implementing the necessary protective measures prior to development.

A detailed study must be completed to determine the need for protection prior to the implementation of protective measures. At the end of 2017, the NVE and others had investigated a total of 275 quick clay zones, and completed or commenced protection work in 145 zones.

SCENARIO

04.1 Rockslide at Åknes

A large rockslide into a fjord with subsequent flood waves would cause severe damage in the areas affected. In order to shed light on how serious the consequences of such an event could be, a risk analysis was conducted of a specific serious scenario in which a 54 million m³ large part of the Åknes rock slope slides into Storfjorden in Møre og Romsdal causing a gigantic flood wave. The original analysis from 2010 was revised in 2016. A separate report was written for the scenario analysis, which documents the results of the analysis in more detail.[34]

Course of events

At the end of June, movements in the Åknes rock slope increase and the NVE raises the risk level to moderate risk and introduces yellow emergency preparedness. After heavy precipitation in August, the movement accelerates to 8 mm per 24-hour period. Orange emergency and preparedness and traffic restrictions are introduced in Storfjorden. At the end of September, the movement reaches a level of several centimetres per 24-hour period. Red preparedness is introduced and a decision is made to evacuate all pre-defined evacuation zones. On Wednesday 15 November at 1035 hours, the entire rock slope moves and the disaster scenario becomes a reality. The flood wave results in an electronic communications outage, road closures, maritime traffic halting, destroyed water and wastewater mains, a partial power outage and major challenges within crisis management, emergency response and rescue.

Time	Scope	Similar events
Evacuation four and a half months prior to the rockslide – clean-up and reconstruction for months and years afterwards.	54 million m³ of rock falls into Storfjorden. This generates a gigantic flood wave with surge heights of up to 70–80 metres, which moves inwards and outwards throughout the entire fjord system.	• The rockslide (approximately 350,000 m³) in Loenvatnet in 1905 resulted in a flood wave of up to 40.5 metres and 61 fatalities. • The rockslide (approximately 3 million m³) in Tafjord in 1934 resulted in a 64-metre high flood wave and 41 fatalities. • The rockslide (approximately 1 million m³) in Loenvatnet in 1936 resulted in a 74-metre high flood wave and 73 fatalities.

Assessment of vulnerability

Seven critical societal functions would be severely impacted by the flood wave(s) and be unable to perform their primary function for a period of time. Within telecommunications, fibre cables and nodes in the transmission network in the surge zone would be destroyed. Traffic restrictions during a prolonged red risk and emergency response phase would present major challenges for transport. Cruise traffic would be stopped when the preparedness level is raised to orange and all maritime traffic – including rescue vehicles – would cease while the fjord is closed during a red preparedness phase. The water and wastewater mains within the surge zones would be destroyed and repairs would take a long time. A number of vulnerable objects and societal functions within the evacuation zone would be moved to alternative locations. Alternative services would last for a long time after the rockslide incident. A large number of local, regional and national stakeholders would be on standby for a long time so they could provide emergency response and crisis management quickly. The capacity and resources of the emergency services would be challenged.

[34] *Report "Risikoanalyse av varslet fjellskred i Åknes", DSB, 2016.*

The innermost fjord villages of Storfjorden would experience power outages, although the utility companies do not believe that a flood wave would impact general supply capabilities. Power would be returned relatively quickly to areas that were not completely destroyed by the flood wave.

Continuous monitoring of the rock slope with the ability to alert and evacuate is one of the barriers that reduces vulnerability.

Assessment of likelihood

The likelihood of the analysed rockslide from Åknes occurring is estimated to be 2 per cent in a 100-year perspective, which results in an annual likelihood of 0.02 per cent and is therefore considered *very low*. The likelihood of a rockslide from Åknes occurring was based on a comprehensive assessment of movement, structural geology and rockslide history. Account was also taken of historical and geological data and frequencies. The likelihood of the event occurring is sensitive to changes in the supply of water or temperature cycles beyond normal seasonal variations. Åknes is a very thoroughly surveyed and monitored rock slope, but each object is individual and represents a complex system and the uncertainty associated with the assessment of likelihood is therefore *high*.

26 objects with an equally high or higher likelihood of a rockslide occurring have been identified. The likelihood of a rockslide occuring in one of these areas in a 100-year period is 40 per cent, i.e. *moderate* likelihood.

Assessment of consequences

The societal consequences of the given scenario are assessed as *large*. The scenario would especially affect the societal assets Economy, Societal Stability, and Nature and Culture. The uncertainty associated with the assessments of the different consequence types varies from *low* to *high*.

Life and health

The number of deaths as a direct and indirect result of the scenario is estimated to be approximately 10. The number of seriously ill and injured people, including delayed injuries, trauma, and post-traumatic stress disorders may reach 100. The limited consequences for Life and health are based on the assumption that advance warning makes evacuation of the population possible.

The long evacuation period and uncertainty associated with when/whether the rockslide would occur increases the likelihood that people would be in the hazard zones when the rockslide occurs and not avoid the flood waves. A rapid evacuation is expected to result in road traffic accidents that result in fatalities and serious injuries. Closed/damaged roads and ferry routes and inability to notify emergency services would mean that people requiring urgent treatment would not receive it in time. During the work of securing, cleaning up and repairing infrastructure, there is a risk of injuries and fatalities among the personnel taking part in the efforts.

The consequences for Life and health have been assessed as small.

Nature and culture

Immense damage will be inflicted on the natural environment below the flood wave's surge height, although the situation would normalise relatively quickly. The fjord landscape would remain untouched.

Shipwrecks on the fjord's seabed, burial mounds, churches and cemeteries within the surge zones are at risk of sustaining irreversible damage or seeing their preservation value substantially reduced. Wooden buildings worthy of preservation in Geiranger, Hellesylt and Dyrkorn would be flooded.

The consequences for the natural environment have been assessed as small, while the consequences for cultural heritage sites and environments have been assessed as very large.

Economy

It is estimated that the direct economic losses would be be very large and ranged between NOK 10 and 15 billion. This includes clean-up, repair and reconstruction costs due to damage to buildings and important infrastructure, as well as the prolonged and extremely expensive evacuation of 800 private households, vulnerable groups and animal populations. Almost 1,500 buildings would be totally or partially destroyed by the flood wave.

The estimated indirect economic losses would also be large and ranged between of NOK 2 and 10 billion. The costs include production stoppages in companies inside the evacuation zones when the risk level is raised to extreme almost two months before the rockslide occurs, and it will take a long time after the rockslide before necessary infrastructure is restored. More than 8,200 employees worked in the region in 2016. Important tourist industry would be hit hard and for a long time. It is estimated that the earnings lost would be high and ranged between NOK 2 and 10 billion.

The direct economic losses would be very large, while the indirect economic losses would be large.

Societal stability

The social and psychological response would primarily be seen in the people living in the affected area and the region around Storfjorden, as well as people who have close relationships with the impacted and affected. It is estimated that reactions of the population in the rest of the country would be small.

Among the affected people, the alert messages and warnings, information and evacuation over long periods of time would in themselves give rise to fear, uncertainty and powerlessness. Moving and evacuating a very high number of inhabitants for a prolonged period of time, including those requiring nursing and care, would create frustration. Experiencing a crisis situation for four-five months before the rockslide occurs, the immense destruction during the emergency response phase and the long-term effects, would entail a very high level of psychological stress.

Nonetheless, the social and psychological response of the public as a whole has been assessed as small.

Many simultaneous events and the outage of electronic communications, including the emergency services' network (Nødnett), would present the police with major challenges with respect to addressing their operational coordination responsibilities and prioritising and directing the emergency services' efforts to where the need is greatest. This could cause negative reactions among the public. The failure of several critical societal functions would lead to serious consequences and disruptions in working and everyday life, especially for the around 17,000 inhabitants in the five innermost municipalities in Storfjorden, which would be the most affected. Power outages, failure of drinking water supply and wastewater systems, and roads closed for months would have a major impact on inhabitants and companies. It is estimated that up to 3,000 inhabitants would have to be evacuated for a period lasting from two months to more than a year.

The stress on daily life has been assessed as large.

Assessment of uncertainty

Åknes is one of seven high-risk objects that are monitored round the clock and several measurement methods are used to ensure high reliability.

Access to monitoring data, historical and geological documentation from similar rockslides, map data for rockslide-prone areas, simulations

of surge heights and risk and vulnerability assessments, as well as consequence assessments, provide a good knowledge base. However, every rock slope is a complex system characterised by large uncertainty.

Given the research, analyses and modelling, as well as historical data, rockslides are considered to be relatively well understood phenomena. However, the focus has been on geology and less on the consequences. No major differences of opinion between the experts were noted during the analysis seminar. The overall uncertainty with regard to the consequence assessments is regarded as *medium*.

The consequences are particularly sensitive to changes in the assumptions regarding alerts and evacuation. The long evacuation period could also make it difficult to maintain control over compliance with the ban on travel and staying in the evacuation zones. The volume of the rockslide also greatly affects the analysis results. Overall, the sensitivity of the results to changes in the assumptions is regarded as *high*.

Overall, the uncertainty has been assessed as large.

Possible measures

Given the results of the analysis, the following measures are suggested:

- Examine how electronic communications options in vulnerable areas can be reinforced. Providers of networks and services need to consider measures that could make the infrastructure more robust.
- In the future, when building, upgrading and rehabilitating, infrastructure owners should consider moving vulnerable installations to areas outside the flood wave zones.
- The emergency response actors should assess actual resource needs and what should be in place in order to manage such an event over a long period of time.
- Include a 'rockslide scenario' when planning major national exercises.
- Explore whether or not drainage aimed at lowering the groundwater level would have a stabilising effect on Åknes.
- Explore who would bear the costs that individual municipalities are unable to meet.
- Clarify who is responsible for compensation following a mandatory evacuation if the warned about rockslide does not occur. ◎

TABLE 8. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario		◎					2% likelihood of the event occurring in a 100-year period.
26 dangerous objects with an equal or greater likelihood have been identified.				◎			40% likelihood of such an event occurring in one of the rockslide-prone rock massifs in a 100-year period.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities		◎				Up to 10 fatalities as a direct or indirect consequence.
	People affected by serious injuries and illness		◎				Up to 100 injuries or ill people as a direct or indirect consequence.
Nature and culture	Long-term damage to the natural environment		◎				200-300 kilometres of coastline affected. Near normal condition restored after ten years.
	Irreparable damage to the cultural environment					◎	26 protected cultural heritage sites and environments would be completely or partially destroyed.
Economy	Direct economic losses					◎	NOK 10-15 billion in repair, compensation and evacuation costs.
	Indirect economic losses				◎		NOK 2-10 billion in lost earnings, delay costs, and reduced production and commerce.
Societal stability	Social and psychological response		◎				The affected people would experience very strong reactions. Reactions in the rest of the Norwegian population would be small.
	Stress on daily life				◎		Critical services and deliveries would be hit hard and for a long time. Up to 3,000 people evacuated for at least two months.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎		The societal consequences have been assessed as large.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY					◎		Overall, the amount of uncertainty has been assessed as *large*.

SCENARIO

04.2 Quick Clay Landslide in a City

Quick clay landslides are relatively common in Norway since there are many areas with marine clay that was previously below sea level. This clay completely liquifies during a landslide. Most quick clay landslides occur in uninhabited areas, but a serious landslide could also occur in a densely populated area. The analysed scenario takes place in a known quick clay zone in the highest risk class, where many people live: Øvre Bakklandet in Trondheim with approximately 2,000 residents.

The risk analysis was conducted in the winter of 2013 and was updated in 2018.

Course of events

Construction work and erosion trigger a large landslide in Øvre Bakklandet in Trondheim. An initial landslide first occurs in which a 10 x 100 metre section slides into the Nidelva River one night in October. Evacuation commences the following day and that night the main landslide occurs. The main landslide immediately causes a flood wave upstream and downstream in the Nidelva River, which hits buildings along the river. The clay completely dams up the river and the water level upstream quickly rises by approximately 12 metres.

Time	Scope	Similar events
48 hours in October.	3 million m³ of clay falls into the river. Approximately 2,000 people live in the 0.5 km² landslide area. An area of 1.5 km² with approximately 1,000 residents is flooded in the centre of Trondheim and on Øya.	• The Rissa landslide in 1978 when 5–6 million m³ of clay flowed out. 20 houses and farms were destroyed and one person was killed. • The Verdal landslide in 1893 was the largest landslide event in Norway in modern times. 116 people lost their lives when 55 million m³ of clay or 3 km2 of Verdal Municipality disappeared along with 105 farms. • The landslide in Sørum in 2016 where 140,000 m³ of clay slid out and three construction workers were killed. The landslide was probably caused by ongoing filling work in the area.

Assessment of vulnerability

Trondheim is especially vulnerable to quick clay landslides because of its multiple large quick clay zones , many of which are densely populated. Excavation restrictions apply in the areas, but it is difficult to monitor and prevent triggering factors such as construction activities and erosion. Quick clay landslides often occur without warning, making evacuation impossible. In the event of an initial landslide (warning), a complete evacuation of the 2,000 residents of Øvre Bakklandet takes several hours. The rescue work after a landslide would be demanding due to problems accessing the landslide area and would rely on helicopters. Local infrastructure such as roads, rail, electronic communications and power supply would be damaged.

Assessment of likelihood

Likelihood estimation is based on the following assumptions:

- That one major quick clay landslide occurs in Norway every year.
- That 80% of these landslides take place in one of the mapped quick clay hazard zones.

The likelihood of a landslide is assessed as somewhat lower than for an average zone due to the erosion protection measures implemented in the river Nidelva, and some control of construction projects.

It is estimated that a landslide could occur in Øvre Bakklandet in 2,000 to 3,000 years. This results in an annual likelihood of around 0.04 per cent. The likelihood of an event occurring in a 100-year period is 4 per cent. This corresponds to a *very low* likelihood on the ACS scale.

If we assume that there are ten areas in the country with a similar risk of landslides as Øvre Bakklandet, the likelihood of a similar scenario on a national basis is 35% in a 100-year period. The scenario falls under the category of *low* likelihood in ACS.

The uncertainty associated with the indication of likelihood has been assessed as medium. Quick clay landslides are a familiar phenomenon and the knowledge base is good. The indication of likelihood is however sensitive in relation to a number of assumptions, such as the defined frequency of major landslides, the degree of risk in this zone relative to the average, and on what control exists over construction work in the area.

Assessment of consequences

Overall, the consequences of the given scenario are assessed as *very large*. The scenario will primarily threaten the societal assets Life and health, Nature and culture, Economy and Societal stability.

Life and health

More than 2,000 people live at Øvre Bakklandet. In addition, there are around 300 people at schools, institutions, etc. daily. Assuming that the entire area was evacuated prior to the main landslide occuring, the number of deaths as a result of the landslide is estimated to be approximately 200. Some people will perish in the initial landslide prior to the evacuation of the area. It is assumed that most people will perish in the main landslide one day later or due to the flood wave. Some inhabitants have not complied with the evacuation order, other inhabitants have returned to collect their belongings when the main landslide occurs.

It is estimated that the landslide will cause 500 serious injuries and that just as many will suffer lasting psychological disorders due to the event.Injuries will occur when people in the area are swept away by the landslide, buildings that collapse, etc.

The consequences for life and health are very sensitive to the assumption that there is time for evacuation before the main landslide. If, for example, only three hours pass between the landslides, the police will not have time to start an evacuation while they perform rescue work after the initial landslide. Geological assessments used as a basis for evacuation will not be available either in such a short period of time. Normally, the main landslide occurs without warning. The number of deaths in a scenario without evacuation will be much higher. It is assumed that at least 1,200 people would perish then, around half of those located in the area

The consequences for Life and health have been assessed as large.

Nature and culture

Damage to nature will be limited to the actual quick clay zone and the adjacent areas that are affected by the clay masses. Landslides and the formation of sludge in the river and fjord are natural processes, and it is assumed that the types of nature that are affected will be restored in the course of ten years. This is a fairly invulnerable brackish water zone, characterized by prior encroachments. The river will be polluted by construction materials and waste, but only from private homes and not from companies. The habitats for red-listed plant and insect species and vulnerable mammals (such as otters) and birds species may be destroyed.

The flooded area will primarily consist of Trondheim's medieval town district, which is a highly-valuable national archaeological cultural heritage site. Several protected cultural heritage sites such as the Nidaros Cathedral, the Archbishop's Manor, and the royal residence Stiftsgården will be lost or significantly impaired. There will also be major damage to other protected buildings in central Trondheim, and valuable recreation areas such as the Pilgrims' Route.

The consequences for the natural environment have been assessed as small, while the consequences for the cultural environment has been assessed as very large.

Economy

It is estimated that the direct economic losses (compensation costs) would be very large and just above NOK 30 billion. The landslide, flood wave and flood will destroy bridges, roads, railways and buildings. The rebuilding costs are based on NOK 25 -30,000 per m^2. At least a thousand homes would be lost, which alone would represent compensation costs of NOK 4-5 billion.

There will also be indirect production losses as a result of the destruction of the premises for an estimated 100 stores and restaurants. With estimated annual earnings of NOK 50 million per business, the lost earnings for all businesses in one month would be around NOK 400 million.

The tourism industry would suffer a high loss of earnings due to fewer tourists and visitors over a longer period. Cultural heritage sites such as the Nidaros Cathedral, the Archbishop's Palace and Stiftsgården generate a large proportion of the tourism in the city, and these would be completely or partially lost in this scenario. A study from 2017 about 'cultural environment tourism' shows that tourists primarily motivated by visiting cultural heritage sites and cultural environments accounted for one-third of the total value creation in the tourism industry in Røros.[35] Transferred to Trondheim, 'cultural environment tourism' accounts for NOK 730 million a year.[36] An estimated halving of this type of tourism in Trondheim for ten years would amount to a loss of more than NOK 7 billion.

The direct economic losses following the quick clay landslide would be very large, while the indirect economic losses would be large.

Societal stability

The landslide would be experienced as frightening, both locally and nationally. Very few people are prepared for a major landslide in a densely populated area. People do not expect the authorities to allow anyone to live in a location that they know is very prone to landslides.

When the ground suddenly fails, it would trigger fear and panic among those in the location concerned. People living in other quick clay areas would also feel anxiety due to what they were seeing and hearing. Many would experience powerlessness and that the situation was outside of their control. An emergency evacuation would also be a frightening experience to many people. Very many people would be indirectly affected as friends and relatives of the dead and injured, and the whole city would be impacted by the event for many years.

The rescue work would be very difficult, and many people would want to enter the landslide area to look for missing people. It would be difficult for local and national crisis management teams to gain an overview of the situation and to warn, evacuate and inform the residents. This would lead to criticism and less confidence in the authorities.

Many people's everyday lives would be impacted after the landslide. The two thousand evacuees would have to live in temporary places for a shorter or longer period of time, and none could move back to the same house. It would take several years before the release area could be used again, although the clean-up of the release area would take less time. If it is not possible to recover all of the dead from the masses of clay, the area make not be redeveloped.

Locally, critical infrastructure such as power, electronic communications, water, roads and railway tracks would be completely destroyed, and it would take up to a month to restore the most important functions. The power grid in the area is finely meshed and robust, so the power outage would not affect a large area.

The consequences for Societal stability would be large.

Assessment of uncertainty

Quick clay landslides are a known phenomenon in both Norway and other countries. Geology and geotechnics are specialist fields that carry out research on landslides. Historical landslide data, landslide databases, mappings of quick clay zones and risk assessments are all available, but there is no experience from such an extensive landslide in a larger city. The knowledge base is regarded as good.

The estimated likelihood is based on a number of assumptions (discussed under likelihood) and the sensitivity to these is high. The number of fatalities and injured would largely depend on the evacuation assumption, whereas the sensitivity associated with the other consequences is considered low.
The uncertainty is regarded as *medium*. This is because the knowledge base is good. However, the sensitivity to changes in the assumptions is large, especially with respect to the consequences for Life and health.

Possible measures

Given the results of the analysis, the following measures are suggested:

- Municipalities should ensure that all quick clay zones are surveyed and mapped, and consider restrictions on buildings and excavation works within the zones.
- Municipalities and the police in municipalities with populated quick clay zones should prepare emergency response plans for rapid evacuation and rescue work in the event of a landslide.
- Municipalities and cultural heritage authorities should survey the cultural heritage sites that could be affected by quick clay landslides and any subsequent flooding, and assess measures for protecting these.

[35] *Menon Economics 2017, "Verdien av kulturarv – en samfunnsøkonomisk analyse med utgangspunkt i kulturminner og Kulturmiljøer". This uses figures from Røros since the survey does not cover Trondheim.*
[36] *Value creation in the tourism industry in Trondheim amounted to NOK 2.2 billion in 2016. Source: http://www.statistikknett.no/reiseliv/okonomi/struktur_region.aspx*

TABLE 9. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODER-ATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario		◎					The likelihood of the scenario occurring has been assessed as 4% in a 100-year period.
Similar quick clay landslides on a national basis			◎				The likelihood of a similar landslide occurring in one of the ten similar quick clay zones in Norway has been assessed as 35% in a 100-year period.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities				◎		200 fatalities due to the landslides and the subsequent flood wave.
	People affected by serious injuries and illness				◎		It is estimated that 500 people would be seriously injured and the same number would suffer psychological disorders in the aftermath.
Nature and culture	Long-term damage to the natural environment		◎				Area with little vulnerability. Restoration of nature within 10 years. Habitats for fish and birds impaired.
	Irreparable damage to the cultural environment					◎	Cultural heritage sites of great national significance would be completely or partially lost, including Nidaros Cathedral and other protected buildings.
Economy	Direct economic losses					◎	More than NOK 30 billion in repair and reconstruction costs.
	Indirect economic losses				◎		Lost earnings of around NOK 7.5 billion due to reduced tourism (attractions destroyed) and temporarily closed commercial buildings in the city centre.
Societal stability	Social and psychological response				◎		The landslide would be experienced as unexpected and frightening for the entire population. The victims would be completely helpless. Many would have to be evacuated. The entire population of Trondheim would be directly or indirectly affected.
	Stress on daily life				◎		Many would be evacuated for a longer period of time. 2,000 residents would have to move. Critical local infrastructure would be out of action for a month.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES						◎	The societal consequences have been assessed as very large.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed as *medium*.

PHOTO VERONICA MELÅ / VG

OSLO, ULLEVÅL HOSPITAL:
Nurse wearing protection against multi-resistant Staphylococcus aureus (MRSA).

05

COMMUNICABLE DISEASES

Background

A communicable disease is defined as a disease or carrier state which is caused by a microorganism (infectious agent) or part of such microorganism or by a parasite which can be transmitted between people. Diseases caused by toxins from microorganisms shall also be regarded as communicable diseases. The Act Relating to the Control of Communicable Diseases[37] defines the term communicable disease that is hazardous to public health as a disease that is particularly infectious, which may occur frequently, have high mortality, or may result in serious or permanent injuries and which, a) usually leads to long-term treatment, possibly hospitalisation, long-term sick leave or convalescence, b) may become so widespread that the disease becomes a significant hazard to public health, or c) constitutes a particular hazard because there are no effective preventive measures or curative treatment for the disease.

Large outbreaks of communicable diseases are normally referred to as epidemics. A pandemic is an epidemic that occurs in a large geographic area and affects a substantial part of the population. The term is not only used for very infectious diseases, such as influenza, but also less infectious diseases (such as the AIDS pandemic). In an emergency preparedness context, the most relevant diseases are those that are infectious and spread rapidly. All societies are vulnerable to diseases that are readily transmitted by droplets and aerosol transmission, which few people, if any, are naturally immune to, and for which there is no (adequate) vaccine or treatment. No society can effectively make itself invulnerable to such diseases.[38]

Diseases that are transmitted from animals to humans, either directly or through food or water, are called zoonoses. Zoonoses can also be the cause of epidemics or pandemics. The Norwegian Veterinary Institute publishes an annual report with findings of infectious agents in fodder, animals and food that cause zoonoses, in addition to cases of zoonotic disease in humans. The Zoonoses Report 2017 shows that there is little transmission of disease between animals and humans in Norway, although the number of reported cases of E.coli infection is increasing.[39] Monitoring shows that the most common zoonosis found in humans in Norway is norovirus, campylobacteriosis, salmonellosis and E.coli enteritis. These are gastrointestinal infections that are often transmitted via contaminated foodstuffs or directly from infected animals.

In 2017, a total of 162 outbreaks of communicable diseases that are hazardous to public health were reported in Norway.[40] This is slightly higher than in 2016, but on a par with the preceding years. The number of people infected varied from two to 230 per outbreak. The most commonly reported agents were norovirus, followed by MRSA (methicillin-

[37] *Act relating to control of communicable diseases (ACT-1994-08-05-44, most recently amended ACT-2017-03-03-8. Lovdata.no.*
[38] *NOU 2000:24 Et sårbart samfunn [Official Norwegian Report 2000:24 A Vulnerable Society].*
[39] *Norwgian Veterinary Institute, 2018. The Norwegian Zoonoses Report 2017. Report 23.*
[40] *Utbrudd av smittsomme sykdommer i Norge [Outbreak of Infectious Diseases in Norway]. Annual Report 2017. Published by the Norwegian Institute of Public Health, Disease Control Division. July 2018, www.fhi.no.*

resistant Staphylococcus aureus), influenza virus and vancomycin-resistant Enterococcus (VRE). Over 60 per cent of the reported outbreaks occured in health institutions – and 40 per cent of the infected in health institutions were health personnel. One third were outbreaks of food-borne diseases. The number has risen compared with 2016, but is somewhat lower than in earlier years.

Since 1510, there have been 18 known pandemics. The time interval between pandemics has varied, normally 10 to 30 years. In the 20th century there were four influenza pandemics: Spanish flu (1918), Asian flu (1957), Hong Kong flu (1968) and Russian flu (1977). Of these, the Spanish flu was the most serious causing 14,000 and 15,000 deaths in Norway.[41]

In April 2009, the World Health Organisation (WHO) issued a warning about an outbreak of influenza based on a new virus in Mexico and the USA. The new virus became the starting point for a new epidemic which, spread throughout the world within a year and infected a large proportion of the population in many countries. In June of that same year, the WHO declared a pandemic, i.e. persistent infection in at least two continents.

In Norway, the first cases of the disease were reported as early as the beginning of May, whereas the main impact hit the country in October/November 2009. Estimates indicate that approx. 900,000 people may have fallen ill with swine flu in Norway. For most people, the influenza manifested as a mild illness, but some people were severely affected. 32 deaths linked to the new influenza were recorded in Norway. The management of the influenza pandemic involved the entire health system in Norway and large parts of society.

In 2014-2016, an outbreak of Ebola virus disease ravaged the West African countries of Guinea, Liberia and Sierra Leone. Ebola is a fatal haemorrhagic fever and is transmitted through direct contact. The outbreak was serious because of the scope and lethality of the disease, and it was the worst Ebola outbreak ever reported. Figures from the World Health Organisation (WHO) show that around 28,600 people were infected and 11,323 died.[42] Incidences of infection were recorded in a total of ten countries.

A new Ebola outbreak started in Congo in May 2018. In the middle of September, almost 150 cases of infection were reported, including almost 100 deaths.[43]

Risk

The Norwegian Surveillance System for Communicable Diseases (MSIS) has monitored infectious diseases in Norway for almost 30 years. Annually there are around 16,000 individual reports of infectious diseases in groups A and B, i.e. the categories with the most infectious diseases.[44] Influenza-like diseases belong to group C.

The number of reports submitted to the surveillance system has increased significantly in recent years. This increase is attributed to a real increase in the occurrence of certain diseases, including food and waterborne diseases and infections caused by resistant bacteria. Accordingly, there is a high likelihood that Norway will be hit by serious infectious diseases.

Influenza pandemics of various degrees of severity are registered globally at intervals of 10–30 years. This means that the frequency of future influenza pandemics is assumed to be higher than one every 100 years, but lower than one every 10 years. However, the likelihood that Norway will be hit by a serious influenza pandemic like the Spanish flu is lower than for influenza pandemics in general. The three other influenza pandemics in the 20th century and the influenza pandemic in 2009 were considerably less serious than the Spanish flu. Due to better health among the general population and a better healthcare system, the consequences of communicable diseases are less severe.

The likelihood of a large outbreak of other infectious diseases globally is difficult to assess. In a longer perspective, the resistance of bacteria to antibiotics will present an ever greater challenge and a creeping crisis as the number of carriers of antibiotic-resistant bacteria increase. In a few decades, we may end up in a 'post-antibiotic era' when infections that currently can easily be treated with antibiotics become fatal again. A British study from 2014 estimated that ten million people a year would die due to antimicrobial resistance in 2050.[45]

A serious infectious disease involving many people becoming seriously ill and dying, would be a huge burden on the national health service.

[41] *Store norske leksikon [Big Norwegian Encyclopaedia] (www.sln.no).*
[42] *http://apps.who.int/ebola/ebola-situation-reports*
[43] *http://www.who.int/csr/don/20-september-2018-ebola-drc/en/*
[44] *T. Bruun, T. Arnesen, P. Elstrøm, K. Konsmo, Ø. Nilsen og H. Blystad: MSIS og tuberkuloseregisteret [Norwegian Surveillance System for Communicable Diseases and the Tuberculosis Register]. Annual Statistics for 2012 and a description and evaluation of the registers. Norwegian Institute of Public Health, www.fhi.no 2013.*
[45] *Review on Antimicrobial Resistance, 2014. Antimicrobial Resistance: Tackling a crisis for the healt and wealth of nations.*

The demand for health services will increase, including diagnosis, ordinary treatment and intensive treatment. At the same time, healthcare personnel will also become ill, and capacity will therefore be reduced. Extra personnel will have to be called in. Treatment of other diseases will have to be postponed to a large degree, with all the burden that this will entail for the people affected. The evaluation of the 2009 influenza pandemic indicated that limited capacity of the small health service units in the districts and limited intensive care at the hospitals constitute a vulnerability.

A pandemic may lead to a large proportion of the population becoming ill simultaneously, and to an even larger proportion staying away from work. Their absence could be due to people becoming ill themselves, having care responsibilities, or a fear of infection, and might lead to major problems in a number of sectors. A high level of absence from work could lead to failure of important societal functions on which the healthcare system depends.

Prevention and emergency preparedness

Norway has a well-established disease control regime, which includes the associated regulatory framework, plans, reporting requirements and routines. This provides a framework and conditions for handling the outbreak of an infectious disease.

The Norwegian National Influenza Pandemic Preparedness Plan assigns management responsibilities and tasks to a number of bodies, both within and external to the health service.[46] The plan is intended to help prevent and limit the spread of infection, illness and fatalities, and to ensure that good treatment and care is provided to people affected by the flu pandemic. The pandemic plan states that the vaccination of the population is the principal strategy for managing the situation. Until a vaccine is available, emergency stocks of antiviral[47] drugs will be used to treat people who come down with the illness. In addition, general hygiene measures will be used.[48]

In June 2015, the Government presented an intersectoral strategy against antibiotic resistance for the years 2015-2020.[49] The strategy employs a so-called 'one-health' perspective, i.e. the proposed measures have a broad focus and are directed a human, land animal and fish health, as well as the environment. The strategy's overarching goals are to reduce the overall use of antibiotics and establish responsible consumption of antibiotics in all sectors, increase the knowledge base and become an international driving force in relation to counteracting antibiotic resistance.

[46] *Helse- og omsorgsdepartementet, Nasjonal beredskapsplan for pandemisk influensa [National Influenza Pandemic Preparedness Plan].*
[47] *Medications that counteract viruses.*
[48] *Hygiene measures such as frequent hand-washing, not coughing towards other people and staying at home in the event of illness.*
[49] *The Ministry of Health and Care Services (2015a), The Norwegian National Strategy Against Antibiotic Resistance 2015-2020.*

SCENARIO

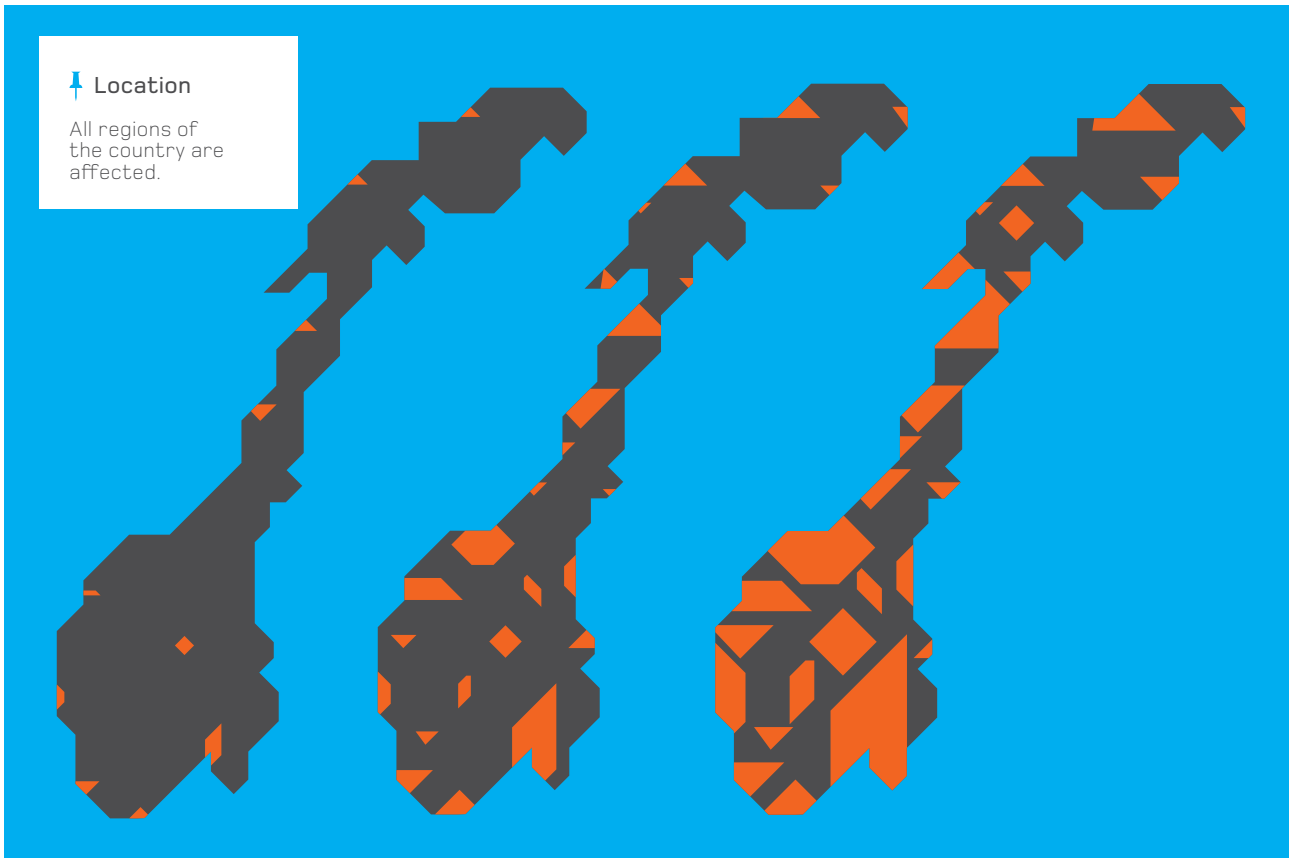
05.1 Pandemic in Norway

A pandemic is a disease outbreak that affects a very high number of people and spreads across large parts of the world. As a rule, pandemics are caused by new, highly contagious and unpredictable infectious diseases. Previous pandemics have largely originated from the flu virus in animals. The WHO decides when a disease outbreak can be considered a pandemic.

The scenario that is analysed is a somewhat downscaled worst-case scenario from the national pandemic plan from 2006, with Thailand as the country of origin.

The risk analysis was conducted in the autumn of 2010, and updated in 2018.

Course of events		
A new influenza virus that is primarily transmitted by droplet infection, with an incubation period of one to two days, is discovered in Thailand in the middle of December. The virus spreads quickly, and the flu pandemic reaches Norway in the middle of January. The pandemic peaks after six weeks and lasts for four months. No vaccine is available in Norway during the course of the flu pandemic, and antivirals have no effect. The young and able-bodied are affected particularly badly.		
Time	**Scope**	**Similar events**
The pandemic is registered in Norway in January, reaches its peak after six weeks and lasts for four months.	• 25 per cent of the population is infected and the disease lasts for approximately 10 days. • 20 per cent of the sick seek medical help, and three per cent of the sick are hospitalized. • 25 percent of the hospitalized need • intensive treatment.	• The Spanish flu in 1918–1919 took the lives of 50–100 million people worldwide. • The Asian flu in 1957 took the lives of 1–2 million worldwide. • The Swine flu in 2009 took the lives of 32 people in Norway.



Assessment of vulnerability

A large number of sick people represents a challenge for all parts of the health sector, both due to high workloads and high sick leave rates. Current intensive care capacity would be insufficent to meet the need in this scenario. Both primary and specialist health services would come under pressure during a pandemic with a high infection rate.

Norway has signed agreements for the delivery of pandemic vaccine doses covering the entire population. The production of pandemic vaccine would depend on the WHO having identified, isolated and prepared the pandemic virus for vaccine production. The first delivery of pandemic vaccine would not be able to reach the Norwegian population until four to six weeks after production started. The vaccine would then be delivered in small partial deliveries over an extended period of time. This means it would take a long time before the entire population could be offered the vaccine.

A pandemic outbreak would result in a high sick leave rate and a lot of people would also stay home to care for sick family members. This could reduce the availability of critical societal functions such as security of supply, transport and health and care services.

Assessment of likelihood

On the basis of the historical frequency of influenza pandemics, there is a high likelihood that Norway will be hit by an influenza pandemic.

Pandemics of various degrees of severity are registered globally at intervals of 10–30 years. In the 20th century there were three pandemic outbreaks in Norway. Increasing travel between countries and continents makes it difficult to limit the spread of disease. Due to better health among the general population and a better healthcare system, the consequences of diseases are less severe. It is assumed that a pandemic as described in the scenario may break out every 100 years in Norway, i.e. an annual likelihood of 1–2 per cent or 75 per cent in a 100-year period. In ACS, this places pandemic in the category of *high* likelihood.

The uncertainty of the estimate of the likelihood is attributed primarily to what type of virus in animals is transmitted to humans. The virus types have different properties with regard to the transmission of the disease and its severity. It is assumed that the virus in this scenario is readily transmitted between humans, and this is not the case with all viruses that are transmitted from animals to humans. The uncertainty of the likelihood estimate is regarded as medium.

Assessment of consequences

The overall consequences of the given scenario are assessed as *very large*. The most serious direct consequences of the pandemic are a large number of fatalities and illness in the population. The scope of health-related consequences is crucial in relation to other societal consequences, such as a high rate of absence due to illness in all sectors, inadequate public transport, damage to the power supply grid that will not be repaired, and poorer medical treatment for other illnesses. The economic losses will also be high because of loss of production and high cost of medical treatment for hospitals.

Life and health

An influenza pandemic has a serious impact, because the people infected can become seriously ill, and many of these could die. The Norwegian Institute of Public Health has developed a "pandemic calculator" based on data the WHO has collected from pandemics throughout the world in recent decades. This calculator shows that a given virus like the one in the scenario will infect 25 per cent of the population and make approximately 1.2 million people sick:

- 20 per cent will visit a doctor, i.e. 245,000 persons.
- 3 per cent will have to be admitted to the hospital, i.e. 36,500 persons.
- 25 per cent of those who are admitted will require intensive care (stay of around 12 days), i.e. 9,188 persons.
- 0.5 per cent of the 1.2 million who become sick will die, i.e. 6,125 fatalities.

An assumption that is made in this calculation is that everyone who requires intensive care receives it. This is possible, but there will be a lack of both equipment and healthcare personnel. Those who are sick and require intensive care for other reasons will also suffer from the same insufficient capacity during the four months the pandemic lasts. On this basis, the number of fatalities is adjusted from around 6,000 to around 8,000 persons.

The estimates of 8,000 fatalities and more than 35,000 seriously ill means that the pandemic outbreak will have the most serious consequences for life and health of all the scenarios that have been analysed in Analyses of Crisis Scenarios.

The consequences with regard to fatalities and ill and injured people have been assessed as very large.

Economy

The direct economic costs are linked to the treatment of infected people. More than 35,000 hospitalisations, including more than 9,000 intensive care treatments lasting 12 days, and 27,000 other hospitalisations lasting ten days, would result in extraordinary costs of more than NOK 5 billion.

The direct economic losses would be large.

A large number of fatalities and extensive absence due to illness will result in high production losses. We assume that 700,000 employees would be away from work for an average of ten days due to their own illness or the need to take care of sick children. In 2017, the average monthly wage for all men and women in different sectors was NOK 44,310. Absence from work due to the pandemic would therefore result in more than NOK 14 billion in lost earnings.

The indirect economic losses has been assessed as very large.

Societal stability

A pandemic is a rare, but known event in many countries, including Norway. All pandemics, however, are different, so the course of events and consequences will be uncertain. It is assumed that the scope of the deaths and illness will result in major psychological effects and the feeling of sorrow, fear and powerlessness. There is little opportunity to avoid a pandemic that affects the entire country and neighbouring countries. In certain cases, pandemics can affect certain age groups in the population that are not usually in the danger zone for infectious diseases such as seasonal flu (e.g. healthy, young people), depending upon previously acquired immunity. The lack of a vaccine can create a feeling of powerlessness and mistrust of the authorities. This will create social unrest.

The social and psychological response of the public has been assessed as very large.

During a pandemic many people will avoid places where there are large crowds and a high risk of infection, such as public means of transport. Public service offerings will be reduced due, for example, to the high rate of absence due to illness.

The stress on daily life has been assessed as medium.

Democratic values and capacity to govern

It is assumed that a high rate of absence due to illness will also affect the central public administration and national politicians.

The impact on capacity to govern has been assessed as small.

Assessment of uncertainty

Pandemics are a relatively well-known phenomenon, and given the scope assumed in the scenario, the uncertainty of the different types of consequences has been assessed as varying from medium to large. Overall, the uncertainty of the assessment of consequences has been assessed as *medium*. The greatest uncertainty is associated with the type of virus and how contagious and pathogenic it is. This will heavily influence the consequences.

Social and economic consequences will also depend on how robust important societal functions are and whether they are prepared to manage an emergency of this type. The public authorities' crisis management skills and ability to communicate well during the emergency are very important.

Possible measures

The Norwegian National Preparedness Plan for Pandemic Influenza contains detailed measures and emergency response plans for ministries and bodies with preparedness responsibilities in a pandemic situation. The action plan is divided into the following thematic areas with the associated division of responsibilities:

- Planning and coordination, which includes maintaining an up-to-date influenza pandemic plan.
- Surveillance and containment, which includes having good surveillance data about annual influenza outbreaks in people and animal, as well as vaccination coverage.
- Prevention and containment, which includes having a strategy for the distribution and use of antiviral drugs and pandemic vaccines.
- Response, which includes maintaining up-to-date emergency response plans and strategies for managing a pandemic in all parts of the health sector and other social sectors.
- Communications, which includes having plans for crisis communication.

TABLE 10. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODER-ATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario					◎		75% in a 100-year period.
Transferability is not relevant.							
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities					◎	Around 6,000 fatalities as a direct consequence of the pandemic and 2,000 due to inadequate treatment for other illnesses.
	People affected by serious injuries and illness					◎	A total of 35,000–40,000 must be admitted to hospital, and approximately 10,000 will require intensive care.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses				◎		More than 35,000 hospitalisations in four months would amount to more than NOK 5 billion.
	Indirect economic losses					◎	NOK 14 billion in lost earnings due to sick leave.
Societal stability	Social and psychological response					◎	Uncertain and frightening consequences, lack of a vaccine, very many are affected.
	Stress on daily life			◎			Reduced public service and public transport.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern		◎				High sick leave rate in government, parliament and the ministries.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES						◎	The social consequences have been assessed as very large.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed as *medium*.

SCENARIO

05.2 Foodborne Illness

In Norway, we are accustomed to ample access to food, and we assume that food will be safe to eat. As well as secure access to food, food safety is also important. Food safety entails the food we eat not containing contagions, environmental toxins or contaminants that will make us sick if we prepare and eat it as intended. An analysis of a foodborne outbreak of enterohemorrhagic E. coli (EHEC) was conducted in 2015. The scenario has been set in Trondheim. A separate report documents the analysis in more detail.[50] The risk analysis was updated in 2018.

Course of events

Two children are admitted to hospital in Trondheim with bloody diarrhoea. Two days later, an elderly woman is also admitted to hospital in Levanger. The admissions are reported to the Norwegian Institute of Public Health (NIPH) as suspected EHEC. On 18 April, one of the children dies of renal failure. Analyses confirm that the EHEC serotype has a rare DNA profile. Over the course of two weeks, more cases occur around the country, although the outbreak is concentrated in Trøndelag. The outbreak is defined as national. Within four weeks, another five people die, four of whom are children. At the same time, a decision is taken to ban imports of iceberg lettuce from Spain. The number of cases of illness decreases. The source of the outbreak is never verified.

Time	Scope	Similar events
A weekday in the middle of April. After eight weeks, no new cases are reported.	• Several locations around the country. • Six fatalities, 275 fall ill and of these 55 experience renal failure.	• EHEC outbreak in Germany in 2011: 4,397 people fell ill, and around 900 developed HUS[51] and there were 55 fatalities. In addition to Germany, 13 other European countries were affected, as were the USA and Canada. • EHEC outbreak in Norway in 2006: The outbreak struck 18 people, primarily children. Ten of the children developed HUS; one of the children died of renal failure.

[50] *Report "Risikoanalyse av matbåren smitte", DSB, 2015.*
[51] *HUS–haemolytic uremic syndrome. A serious haematological and kidney disease that results in a fever, reduced platelets, damage to small blood vessels, anaemia due to the destruction of red blood cells and varying degrees of renal failure.*

Assessment of vulnerability

Norway has better control over serious communicable diseases than most countries. This is due to high hygiene standards, good living conditions, high vaccination coverage, good animal health and generally well-developed infection control that quickly identifies outbreaks of communicable diseases and makes it possible to implement measures quickly.[52] Increasing imports of food from countries with a different epidemiological situation than Norway increases infection pressure and may result in a higher number of incidents in coming years.[53] The growing globalisation of food production, increased travel and new foods, ingredients and production methods will also increase infection pressure.

The duration of the outbreak will represent a challenge for the emergency preparedness in municipalities, counties and nationally with respect to capacity and resource use over time.

Food supplies would be minimally affected and the ban on imports of some foods would not lead to food shortages. A large number of seriously ill people would result in a great need for treatment and this would reduce the capacity to offer a high number of children HUS dialysis treatment. 55 children with HUS would exceed treatment capacity in the Trøndelag region.

A high number of tests on foods from patients' homes and from affected businesses would pose a huge burden on laboratories because the number of submitted bacterial cultures would rise dramatically.

Assessment of likelihood

Foodborne infections have become a growing health problem in the industrialised world in recent decades. This is primarily due to changes in livestock husbandry, food production and trading patterns. In addition to harmful contagions finding their way into in the food chain, they also spread globally.

In the last few years, there has been as significant increase in serious E.coli infections. There have been many outbreaks and the infections have caused renal failure and some fatalities among children. The reason for this increase is unknown.

The lessons learned from Germany (where HUS has been reportable since 2001) show that HUS primarily strikes children under ten years old and that these children have a 50 to 100 times higher risk of developing HUS than older patients.[54]

Based on the current occurrence of E.coli infections, it is estimated that an event similar to the scenario could occur once in a 100-year period, i.e. there is a 1 per cent likelihood of it occurring in a one-year period. This results in a 65 per cent likelihood of it occurring in a 100-year period, which corresponds to *moderate* likelihood.

There are different strains of enterohemorrhagic E. coli (EHEC). Similar outbreaks of foodborne infections can also occur via other foods and in other places. The likelihood of a similar scenario occurring on a national basis has therefore been assessed to be 75 per cent in a 100-year period, i.e. *high* likelihood.

Assessment of consequences

Overall, the societal consequences of the given scenario have been assessed as *small*. The scenario entails medium consequences for the societal assets Life and Health, and small to medium for Societal Stability. The consequences for Economy have been assessed as very small.

Life and health

HUS is characterised by renal failure. HUS causes the abnormal destruction of red blood cells and at the same time blood clots form in the body's smallest blood vessels. When this happens in the kidneys, renal function is impacted, and this can lead to renal failure. Blood clots can also form in other organs and cause these to fail. Renal failure may necessitate dialysis and some patients may need kidney transplants. The condition can be fatal.

The scenario assumes that 275 people will become seriously ill, 55 will develop HUS (primarily children) and six people will die (four children and two adults). Even though there are cases of illness around the country, the Trøndelag region is hit especially hard.

The consequences in terms of fatalities have been assessed as small, while for serious injuries and illness they have been assessed as medium.

---

[52] *Meld. St. 34 (2012–2013) – Public Health Report.*
[53] *Meld. St. 19 (2014–2015) – Public Health Report.*
[54] *Incidence of 1.38 per 100,000 for patients under 10 years and 0.02 per 100,000 for patients over 10 years of age. (Source Robert Koch-Institut, SurvStat, http: //www3.rki.de/SurvStat, Date: 22.11.2006)*

Economy

It is estimated that the direct economic losses would amount to around NOK 100 million. This includes extraordinary costs in the health service, the withdrawal of products from the market, the possibility of the wrong foods being designated as the source of infection, any claims for compensation, and extra costs associated with identifying the source of infection, tracking in the food chain and analysing tests. It is estimated that the indirect economic losses would also amount to around NOK 100 million due to, among other things, lost earnings and business interruption.

The direct and indirect economic losses have been assessed as very small.

Societal stability

It is not known which foods carry the contagion and must be avoided. General advice would be issued and it is assumed that this would decrease potential anxiety to some extent. The fact that the source of infection is unknown and that the contagion strikes vulnerable groups would create uncertainty and anxiety, especially in families with young children. The outbreak primarily strikes the Trøndelag region, and it is assumed that the level of anxiety would be greatest here, while the population of the rest of the country would be less likely to experience unease and anxiety. The relatively long duration of the outbreak would generate a great need for information among the public.

The social and psychological response of the public has been assessed as moderate.

Parents would have to stay home from work to care for children who are kept home from kindergarten/school in affected parts of the country. The children would not necessarily become very ill, but the infection control regime would have to be maintained. This means that they would have to be kept home for kindergarten for 48 hours after they have been declared free of symptoms.

Hospitals providing treatment might have to put on extra shifts if dialysis capacity is to be fully utilised.

The stress on daily life has been assessed as small.

Assessment of uncertainty

Foodborne infections are a known phenomenon and the incidents seen in the last few decades have been thoroughly evaluated. We have good experience from outbreaks, and the access to relevant data is good. The division of responsibilities and tasks regarding food safety and health services is clearly described, and cooperation between the actors has been established. There is also extensive cooperation on infectious diseases and food quality. Norwegian authorities has dealt with far greater outbreaks caused by other contagions, such as Salmonella, but has limited experience of dealing with large outbreaks of E. coli infection. The knowledge base is regarded as good.

Small changes with respect to season, which foods are infected and which bacteria are involved, could have a major impact on the assessments of the consequences. Other factors that affect the consequences are the time it takes to identify the source of infection and how the authorities communicate with the public. The number of fatalities will largely depend on early diagnosis and good treatment. The sensitivity associated with the consequences has been assessed as *medium*.

Overall, the uncertainty has been assessed as medium.

Possible measures

Foodborne infections are a high priority and are closely monitored by the Norwegian authorities. However, changing food habits and increased imports of fresh produce also provide more opportunities for individual cases and outbreaks of foodborne diseases in Norway. In the long term, it is possible climate change may lead to a shortfall of irrigation resources in countries we import food from, changes in production methods and changes in trading patterns. This may present new challenges in relation to food safety.

Given the results of the analysis, the following measures are suggested:

- Strengthen the surveillance and notification of food and waterborne contagions in patients and in the various links of the food chain, including in imported food, through surveillance programmes and the daily work of reference laboratories.
- Enhance the cooperation between reference laboratories.
- Strengthen national and international communication and notification lines and improve international cooperation in the event of outbreaks.
- Identify sources of infection and risk factors for diseases through microbiological and epidemiological surveys as background information when an outbreak occurs.
- Improve food producers' and importers' awareness of the dangers associated with EHEC and other contagions, and intensify supervision to ensure that businesses that represent a risk fulfil their food safety responsibilities.

TABLE 11. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODER-ATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario				◎			65% likelihood of the event occurring in a 100-year period.
Similar events on a national basis					◎		75% likelihood of a similar scenario occurring in a 100-year period on a nationwide basis.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities		◎				Six fatalities.
	People affected by serious injuries and illness			◎			275 seriously ill, and 55 severely ill who require advanced treatment.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses	◎					Withdrawing products from the market, identifying the source of infection, tracking in the food chain, analysing samples, etc. would result in a total loss of approximately NOK 100 million.
	Indirect economic losses	◎					Disruptions to business, kindergartens and major institutions due to closures, reduced productivity, etc. would result in a total loss of approximately NOK 100 million.
Societal stability	Social and psycho-logical response			◎			Foodborne infections would be experi-enced as serious and disturbing. Great-est impact on children, the sick and the elderly. Uncertainty about the source of infection and the great need for information would cause anxiety and fear among the public.
	Stress on daily life		◎				Parents would have to stay home from work due to closed kindergartens, and the maintenance of the infection control regime would make this relatively pro-longed.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES			◎				The social consequences have been assessed as small.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed as *medium*.

SCENARIO

05.3 Disease Outbreak with Antibiotic-Resistant Bacteria

Antibiotic resistance is an ever-increasing challenge for public health that could gradually force the health service back into a pre-antibiotic situation, where even simple infections can become life-threatening. Antibiotic resistance in bacteria means that they can reproduce even after being exposed to antibiotics. The incidence of antibiotic resistance in Norway is relatively low, although a combination of increased consumption and the misuse of antibiotics, increased international trade, increased travel and a failure to develop new antibiotics has resulted in the ever-faster emergence and proliferation of resistant bacteria.

A risk analysis of a concrete scenario was conducted in the autumn of 2017. The analysis is documented in separate report.[55]

Course of events

In the orthopaedic ward at Vestfold Hospital Trust, an elderly woman is diagnosed with a postoperative wound infection caused by multi-resistant Staphylococcus aureus (MRSA). Relevant infection control and contact tracing measures are immediately implemented in the orthopaedic ward and in the nursing home where the elderly woman lives.

In the following weeks, MRSA is detected in patients/residents and staff at the hospital and the nursing home. Bacterial tests confirm that the MRSA from the various infected individuals is of the same strain that is also believed to be transmitted to and from pig herds.

Vestfold Hospital Trust, a nursing home, a pig herd and a visitor farm are especially hard hit.

Time	Scope	Similar events
The first case of MRSA is detected in September, and the outbreak lasts for six months.	• More than 200 people test positive as carriers, and 56 are infected by the MRSA strain associated with the outbreak. • MRSA is detected in two pig herds.	• In 1991–1992, there was a major outbreak of MRSA in three hospitals in East Northamptonshire in the UK. 400 patients were infected, seven of whom died. 196 patients were placed in isolation. • In 2015, MRSA infection was detected in 15 children and four employees in the newborn intensive care ward at the University Hospital of North Norway. • In 2015, LA-MRSA was detected in a breeding herd in Rogaland. A total of six herds were affected and 4,500 pigs were culled.

[55] *Report "Risikoanalyse av antibiotikaresistens: Utbrudd av MRSA i Vestfold", DSB 2017.*

Assessment of vulnerability

A well-established infection control regime for both public and animal health is an effective barrier against the spread of antibiotic-resistant bacteria. The authorities are also systematically working to reduce the use of antibiotics in the primary and specialist health services in order to prevent the constant emergence of new antibiotic-resistant bacteria. Meanwhile, antibiotic resistance is a global challenge and public health in Norway is being affected by the increasing spread of antibiotic resistance.

Given the assumptions in the analysis, the consequences of such a MRSA outbreak would be significant for the health service and the pork industry in the county, although the crisis would largely be handled at a local level. However, the Norwegian Institute of Public Health (NIPH) and the Norwegian Food Safety Authority would have to provide assistance to the municipalities and other actors involved in managing the outbreak.

In the event of an extensive MRSA outbreak, the capacity of the health and care services would be challenged due to the large number of patients that would have to be isolated and monitored, at the same time as the capacity of the hospital and hospital laboratory would be put under pressure. The situation would be further exacerbated if MRSA infection were detected in health professionals at the hospital and nursing home and they had to be put on sick leave or reassigned for an extended period of time.

Assessment of likelihood

MRSA outbreaks in the population and pig herds are highly likely, and generally occur every year. However, the specific scenario on which this analysis is based assumes an MRSA strain that is more contagious and pathogenic than what is currently normal, that circulates in pig herds, and that can be transmitted between humans and animals, and between people. We estimate the annual likelihood of an MRSA outbreak as described in this scenario to be 0.3 per cent, or 25 per cent in a 100-year period. According to the categorisation in ACS, this corresponds to *low* likelihood.

A similar MRSA outbreak could occur across the entire country based on the same assumptions used in this scenario, although there are some geographical differences in relation to the number of pig herds. The analysis results would be representative of other types of infectious disease outbreaks that require prolonged isolation of the infected people, even though there are only a few other types of antibiotic-resistant bacteria that can be transmitted between animals and humans.

The likelihood of a serious outbreak of antibiotic-resistant bacteria that can be transmitted between animals and humans on a national basis has been assessed as *moderate* (65 per cent in a 100-year period).

However, determining the likelihood of biological phenomena of this kind is very difficult, as reflected by the fact that the uncertainty associated with the appearance of such a virulent MRSA strain has been assessed as very large. Bacteria constantly mutate and adapt, and such a MRSA strain and a similar scenario, therefore, cannot be ruled out.

Assessment of consequences

The societal consequences of the given scenario have been assessed as *small*. The most serious societal consequences are related to social and psychological response among the public. A more exhaustive description of the assessments can be found in a separate report.[56]

Life and health

During the six months the outbreak scenario lasts, more than 200 people test positive as a carrier of MRSA, 56 develop an MRSA infection and nine people die, including two children and two elderly people.

Implementing the infection control regime for the 56 isolated patients would be highly resource-intensive and have consequences for those who are isolated, and other hospital patients and staff. In practice, the patients in isolation would receive less treatment than they would under normal conditions. The MRSA infection would also be experienced as distressing and frightening by many patients and relatives.

Nonetheless, the consequences with respect to fatalities and serious injuries and illness have been assessed as small.

Economy

The economic losses would encompass both direct and indirect losses incurred in the health service/healthcare institutions (hospital and nursing home) and pork industry, and by private individuals and businesses because of the incident.

[56] *Report "Risikoanalyse av antibiotikaresistens: Utbrudd av MRSA i Vestfold", DSB 2017.*

It is estimated that the direct economic losses would amount to around NOK 200–300 million. As far as the health service is concerned, the cost drivers would be linked to surveying activities, contact tracing, analysing samples, infection control measures, treating carriers and treating infections. As far as agriculture is concerned, the cost drivers would be linked to contact tracing, testing of pig herds, implementing infection control measures and culling, destroying and then rebuilding herds.

It is estimated that the indirect economic losses would amount to around NOK 100–200 million. The cost drivers would be linked to lost earnings in the hospital due to a halt to admissions, hospital staff being put on sick leave due to MRSA being detected, lost working hours for patients that have to be isolated and other extraordinary costs in the health service in the form of transferring patients to other hospitals, extra cleaning and so on. As far as agriculture is concerned, the indirect losses would be linked to, among other things, lost earnings and disruptions to operations that result in reduced earnings. An outbreak of MRSA infection could have negative consequences for pork sales.

The consequences for the societal asset Economy would be small.

Societal stability

There is reason to assume that the response of the public to an outbreak of resistant bacteria would be wide-ranging. The outbreak would be a top story in the local and national media for a long time, especially given the lives lost to MRSA. Headlines such as 'deadly bacteria spreading' would reinforce a widespread sense of it being an unresolved and alarming situation. Uncertainty about how contagious and pathogenic the MRSA is would result in speculation and great anxiety among the public, and especially on social media. Even if the media management was well coordinated across the various authorities involved with a common message, the limited information about the outbreak would initially cause great anxiety.

The social and psychological response of the public has been assessed as large.

An increase in people visiting general practitioners and emergency wards in the county demanding to be tested for MRSA could cause capacity problems and create some disruption to daily life. Similarly, the scenario would challenge the analysis capacity of the laboratories. Parents who chose to stay at home with their children, or to stay home from work for fear of being infected, could, to some extent, disrupt working life.

The stress on daily life has been assessed as small.

Assessment of uncertainty

The knowledge base about antibiotic resistance in general is good, both nationally and internationally. A greater range and prevalence of antibiotic-resistant bacteria also provides more experience and knowledge about the phenomenon and its consequences, both in terms of prevention and management. However, there is little empirical data concerning events of the scale outlined in the scenario, where MRSA is being transmitted between animals and humans and between people. The uncertainty associated with the emergence of biological phenomena is generally very high. The uncertainty of the likelihood of such an outbreak has, therefore, been assessed as *very large*.

The assessment of consequences is highly sensitive to the bacteria's pathogenic potential and properties. The time it takes to realise that an outbreak is occurring is also significant for the spread of infection and outcomes. The uncertainty of the assessment of consequences has been assessed as *medium*.

Given this, the overall uncertainty has been assessed as large.

Possible measures

- Hospitals and nursing homes must have an up-to-date emergency plan based on risk analyses, particularly in relation to staffing capacity, establishing isolation wards and infection control measures in a serious outbreak situation.
- The organisation of the work on infection prevention, hospital hygiene and infection control should be clear in hospitals and nursing homes, and should be a constant focus.
- Information materials should be prepared for the public, and a clear and conscious media strategy should be in place for the use of social media during an outbreak, set out on action cards linked to the emergency response plans.
- Infection control training in Norway should be enhanced, both as a separate training programme and as part of nursing education.

TABLE 12. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario			◎				25% likelihood of such an incident event occurring in a 100-year period
Outbreak of antibiotic resistant bacteria which transmits between animals and humans in other parts of the country				◎			65% likelihood of a similar outbreak of antibiotic-resistant bacteria occurring on a national basis, based on the same assumptions used in this scenario.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities		◎				Nine fatalities as a direct consequence of the MRSA outbreak.
	People affected by serious injuries and illness		◎				56 people infected with MRSA.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses		◎				Around NOK 200–300 million linked to surveying activities, contact tracing, infection control measures, treating carriers, treating infections and culling pug herds.
	Indirect economic losses		◎				Around NOK 100–200 million linked to lost earnings in the hospital and in agriculture, lost working hours for patients, and other extraordinary costs in the health service.
Societal stability	Social and psychological response				◎		Although the phenomenon is to some extent known, the high level of infection and uncertainty, and the course of events and consequences would create a sense of insecurity, impotence and despair.
	Stress on daily life		◎				Insufficient access to health services. Working life could be disrupted by workers staying home.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES			◎				The social consequences have been assessed as small.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY					◎		Overall, the uncertainty has been assessed as *large*.

FOREST FIRE:
Forest fire in Sel in Gudbrandsdalen.

PHOTO JØRN B. OLSEN - ROLF SØRENSEN / SAMPHOTO

06

FOREST AND WILDERNESS FIRES

Background

Significant environmental, financial and quality-of-life assets are linked to forests and wilderness. Forest areas in particular are of great importance to climate and biological diversity. Forests provide a basis for commercial activities and value creation in the production and processing of timber and wilderness products, and they constitute areas for outdoor experiences and recreational activities Fires put many of these assets at risk. Most fires in the wilderness in Norway are relatively small, but under specific conditions, minor fires can rapidly develop into conflagrations in which for instance thousands of acres of forest burn down, or large areas of wilderness are affected by fire. When forest and other wilderness fires arise, it is no longer just the loss of forest areas and the assets linked to them that are at risk, but also buildings, infrastructure and, in worst case, human life.

In June 2008, the largest fire in Norway in recent times occurred in Froland municipality in Aust-Agder. At its peak, a total of 790 men and 15 forest fire helicopters were involved. The settlement of Mykle was in danger for a period of time, 77 people were evacuated, and it took 13 days for the fire to be completely extinguished. During the course of this period, 19 km^2 of productive forest had burnt down. No human lives were lost during the blaze, but around 20 cabins, several high voltage pylons and hundreds of metres of high and low voltage lines were destroyed. The total cost of the forest fire is estimated to be around NOK 100 million.

Three of the largest fires in Norway in recent times occurred during 11 days in January 2014, when a residential fire in Lærdal spread to 40 buildings and 17 homes were lost. On Sørnesset peninsula in Flatanger Municipality in Nord-Trøndelag, sparks from a power line fell onto dry grass and started a fire. The fire spread across large parts of the peninsula due to strong winds and set buildings in the settlements on fire. 64 buildings, 23 of which were residential houses or holiday homes were lost. On Frøya in Sør-Trøndelag, approximately 10 km^2 of heath and grassland caught fire. One building was destroyed. All three fires entailed extensive evacuation. Common to these fires is that they were large on a Norwegian scale in form of complexity or scope. The total cost of the three fires is estimated at several hundred million Norwegian kroner.

The summer of 2018 was hotter and drier than normal, and the number of forest and wilderness fires, and fires in pastures and arable fields, was very high compared with previous years. A total of 887 forest and wilderness fires were recorded, more than twice as many as in the previous two years.

A total area of 33 km² caught fire. On the most hectic day, 114 simultaneous fires were recorded.[57] At the peak, the DSB had 22 helicopters in operation and on standby.

Risk

In Norway, areas with typical inland climate consisting of hot, dry summers, are those at most risk of forest and wilderness fires.[58] Normally, the most hazardous time of year for fires is spring and early summer, when the forest floor is still covered by tinder-dry, highly flammable plant matter from the previous growing season. Most of the forest and wilderness fires, and also the largest fires, therefore usually take place from end of April to mid-June. After that, grass and green forest-floor vegetation emerges and the risk of forest fires diminishes. In general, the forest fire risk increases in dry, warm weather.

Almost all fires in nature are caused by human activity in one form or another. In particular, burning brushwood, grass, straw and bonfires, and children playing with fire, are the cause of many fires.[59] The only natural cause of a forest fire is a lightning strike, but only a small proportion of the forest fires in Norway are usually caused by this.[60] However, in the summer of 2018, several of the fires were initiated by lightning strikes due to periods of intermittent rain combined with hot, dry weather.

On average, around 1,100 forest fires start in Norway each year, but the vast majority (80%) affect less than 5,000 m² of forest, while just 2% affect more than 100,000 m².[61] Looking at major forest fires in which more than 1 km² of productive forest have been lost, statistics show that there have been nine fires of that type since 1945.[62] Roughly speaking, this means that, on average, Norway experiences one forest fire of this order of magnitude every ten years. The fires we experienced in January 2014 were in heath, scrub and grass, not in productive forest.

There can be several consequences of forest and wilderness fires. As regards to nature and the environment, these fires can mean anything from a slight impact to drastic changes in ecosystems. For some animals and plants that are directly affected, a fire can be disastrous, whereas for other species, a fire is a necessity for the continued existence of those species. Forest fires release carbon from the forest's carbon store and thus affect both the concentration of climate gases in the atmosphere and the reflection of solar energy from the burned areas. The scope of forest fires in individual countries is therefore included in the climate gas accounts, which are reported to the Climate Convention.[63]

Large, out-of-control fires can also imply a danger to human life and health. Fire and smoke damage can produce acute and chronic injuries, and, in the worst cases, claim lives. Rescue and fire crews, in particular, are exposed to great risk, while the possibility of evacuation means that the risk to life and health of the rest of the population can be limited. In Norway, lives are seldom lost as a consequence of forest and wilderness fires. However, a firefighter died in 2018 while fighting a forest and wilderness fire in Akershus.

There have been forest fires abroad in which dozens of people have died. In July 2018, 91 people died in violent forest fires that got out of control in the Attika region to the east of the Greek capital, Athens. In November 2018, there were several violent forest fires in California. The fires were described as the most deadly in the USA in over 100 years.

Buildings and infrastructure can also be lost in forest and wilderness fires. Apart from the economic losses linked to this, the failure of infrastructure can imply challenges for public services, trade and industry, and households. In the event of such fires, fire-fighting is made a priority and is concentrated on built-up areas or where there are particularly important buildings. Establishing firebreaks and spraying foam on buildings are important measures to limit the damages.

Depending on scope and duration, the economic losses from forest and wilderness fires can be significant. In Norway, it is estimated – as a rule of thumb – that a hundred hectares of burnt productive forest is equivalent to approximately NOK 1 million in timber. Added to that is the reduced potential for the wilderness industry, and costs from the loss of buildings and infrastructure. Significant costs are also linked to managing and fighting the fire, characterised by being both of long duration and resource-intensive. In

[57] *July 12 2018, BRIS, DSB.*
[58] *Norway's Forestry Extension Institute (2009): It won't happen to us... – about forest fires and forest fire prevention.*
[59] *Bleken et al. (1997): Skogbrann og miljøforvaltning. En utredning om skogbrann som økologisk faktor. [Forest Fires and Environmental Management. An Investigation into Forest Fires as an Ecological Factor.]*
[60] *Ibid.*
[61] *Report to the Storting (white paper) No. 10 (2016-2017) Risk in a Safe and Secure Society.*
[62] *Directorate for Civil Protection and Emergency Planning (2008): Rapport fra arbeidsgruppe - Skogbrannberedskap og håndtering av den senere tids skogbranner i Norge. [Report from Working Party - Forest Fire Preparedness and Management of Forest Fires in Recent Times in Norway.]*
[63] *http://www.miljodirektoratet.no/no/Publikasjoner/2016/April-2016/Greenhouse-Gas-Emissions-1990-2014-National-Inventory-Report/*

Froland, for example, the costs of fighting the fire constituted around one third of the total costs. The frequency and scope of forest fires vary depending on the type of forest, topography, and climatic conditions, such as drought and wind, as well as our ability to limit and extinguish the fires. Changes in these conditions therefore affect the risk linked to forest fires. From the 1970s up to the 2000s, the number of forest fires per year and the area of forest acreage burnt annually have shown a downward trend.[64] However, the variations from year to year are huge.

It is uncertain how climate change will affect the risk picture. If the development goes in the direction of less snow in lowland areas in the winter, more wind, higher temperatures and periods with drought, this will yield an increased risk with regard to both frequency and scope.[65] According to the report "Klimaendringer og betydning for skogbruket" ["Climate change and its significance for forestry"], the number of days when forest fires may be a hazard may almost double in the period of 2017–2100.[66] The fires in the winter of 2014 and summer of 2018 may be an indication of what we can expect in the future.

Prevention and emergency preparedness

Emergency preparedness encompasses the ability to detect, give warning and fight forest and wilderness fires.

It is in the early phases that a forest fire can most readily be extinguished, and the spread of the fire prevented. This is especially important during conditions with an increased risk of forest fire. It is therefore important to respond quickly and with greater use of resources in an early phase than the severity of the fire indicates normally.

In Norway, the local fire services are responsible for fighting forest fires within their own areas. When required, the state can assist the fire service with resources. This may be both in the form of know-how and physical resources, such as helicopters and support from the Norwegian Civil Defence.

The Norwegian Meteorological Institute (MET) produces a forest fire index for just over 100 locations across the country. The risk of a forest fire is calculated for a specific location where the MET has recorded precipitation, temperature and air humidity, and is not always representative for a larger surrounding area.[67]

Improved monitoring using aircraft and satellites has resulted in the earlier detection of fires. Enhanced road network and improved firefighting equipment and methods have contributed to fires not being allowed to develop as freely. Since the mid 1980's, the use of fire service helicopters for support during major, fairly inaccessible forest fires has also been significant in the management of forest fires. Forest fire helicopters are on permanent standby from 15 April to 15 August, normally stationed at Torp in Vestfold. If there is an increased risk of forest fires in other parts of the country, they can be stationed at other bases. During periods when the risk of forest fires and forest fire activity are high, the DSB allocates more helicopters on standby. The use of the forest fire helicopters is coordinated by the Joint Rescue Coordination Centre (JRCC) for Southern Norway and is administered by the DSB. In addition to civilian helicopters, the Norwegian Armed Forces may be asked to contribute with resources in the event of a forest fire.[68] Norway can also ask for assistance from the EU via the European Response Coordination Centre (ERCC). Sweden needed such international assistance for an extended period of time to deal with forest fires in the summer of 2018. The Norwegian fire and rescue services provided firefighting assistance in Sweden during that period.

[64] *Bleken et al. (1997): Skogbrann og miljøforvaltning. En utredning om skogbrann som økologisk faktor. [Forest Fires and Environmental Management. An Investigation into Forest Fires as an Ecological Factor.]*
[65] *Directorate for Civil Protection (2008): Rapport fra arbeidsgruppe - Skogbrannberedskap og håndtering av den senere tids skogbranner i Norge. [Report from Working Party - Forest Fire Preparedness and Management of Forest Fires in Recent Times in Norway.]*
[66] *MET, no. 25/2014 "Klimaendringer og betydning for skogbruket".*
[67] *https://www.met.no/vaer-og-klima/ekstremvaervarsler-og-andre-farevarsler/vaerfenomener-som-kan-gi-farevarsel-fra-met/varsel-om-skogbrannfare*
[68] *Report to the Storting (white paper) No. 10 (2016-2017) Risk in a Safe and Secure Society.*

SCENARIO

06.1 Three Simultaneous Forest Fires

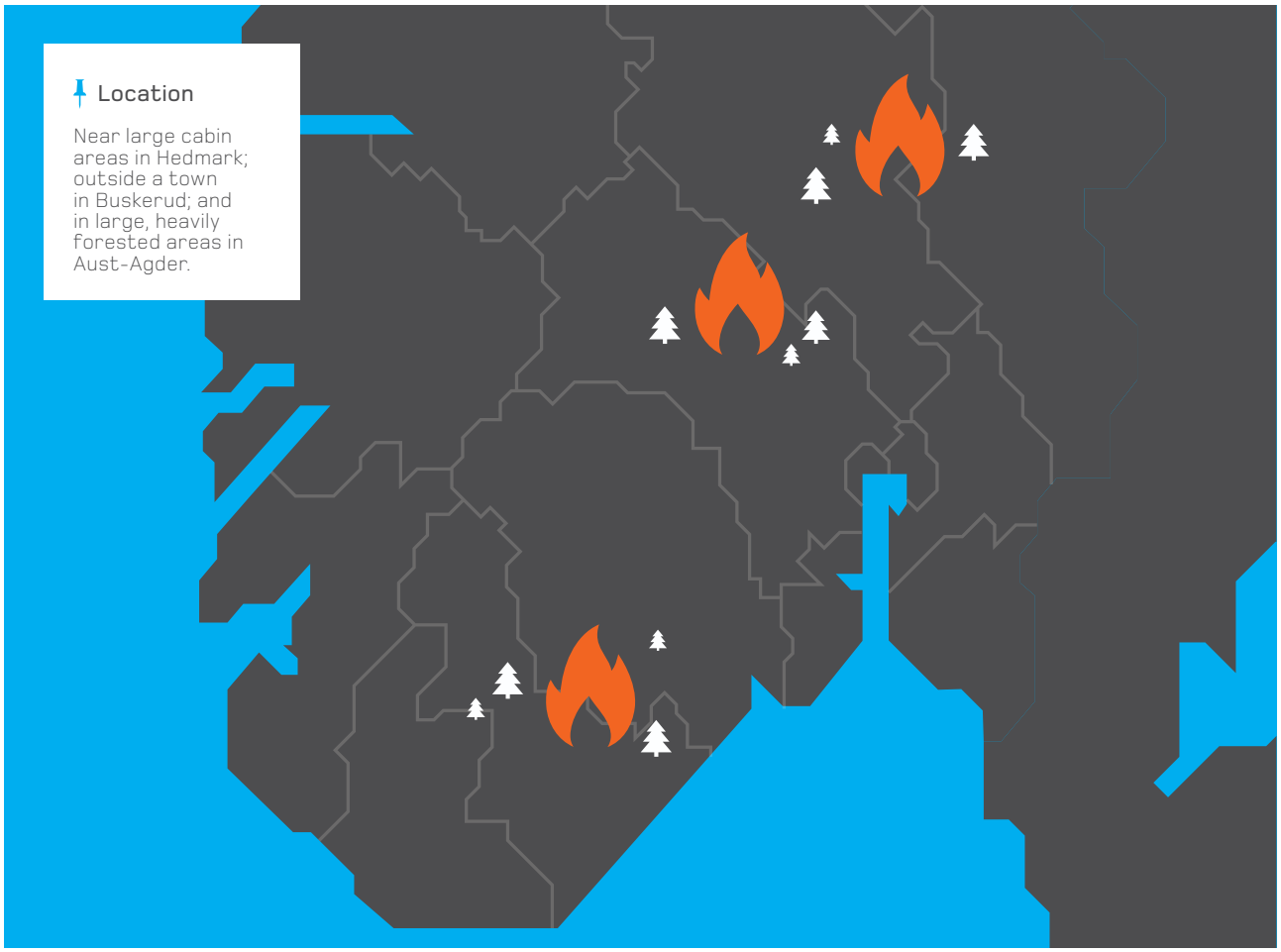
Several simultaneous major forest fires that get out of control would strain Norway's capabilities and have serious consequences for life and property. In this scenario, several fires occur due to strong winds in areas experiencing a prolonged drought. Each of the three forest fires are as large as the Froland fire, which is the largest forest fire in Norway since World War II.

The risk analysis was conducted in the autumn of 2011 and was updated in 2018.

Course of events

An extended period of drought has resulted in an extremely high risk of forest fires in southern and eastern Norway. A number of minor forest fires ocurres, and incipient fires are being stopped on a daily basis. During the course of two days, three fires break out and get out of control. In Hedmark, the forest fire is threatening large cabin areas, in Buskerud, densely populated areas are in danger, while the fire in Aust-Agder is spreading in large, heavily forested areas. There is a stiff breeze from southwest and the strong wind lasts for two days.

Time	Scope	Similar events
May/June. A total of four to six days pass before all of the fires are under control, and an additional week passes before the fires are extinguished.	• Wind speed: Stiff breeze from southwest (15 m/s) that lasts for two days before it subsides. • 100 km² of forest is affected.	• The 2008 forest fire in Froland burnt down approximately 30 km² of forest in six days, before it came under control. • Summer of 2018: In one day, 114 forest and wilderness fires were reported in Norway. There were at least eight simultaneous major forest fires in Sweden.



Assessment of vulnerability

There are natural barriers to fire across large connected areas in several places in Norway, due to mountains, valleys and access to water both on the coast and inland. On the other hand, topographical conditions can make it difficult for ground crews to get to the location of a fire and they are often dependent on helicopter assistance. After the Froland fire, emergency preparedness changed its orientation with regard to forest fire helicopters, and more helicopters are now being put on standby if the situation indicates this is necessary. Norway is poorly suited to the use of special aeroplanes to fight forest fires because the water sources are often too small to fill the tanks of a moving aeroplane.

The simultaneity of the three fires in the scenario makes it even more difficult to prioritise limited helicopter and other resources for firefighting to locations where the risk to life and health and material losses is regarded as greatest.

Being organised into decentralised local fire services results in rapid emergency response times and relatively large ground crews with the necessary local knowledge of the areas. On the other hand, small groups of experts can be vulnerable in the event of complicated, long-lasting events. The Norwegian Civil Defence are an important additional resource for the fire service.

Assessment of likelihood

An assessment has been made of the likelihood of three simultaneous major forest fires in Norway, that all get out of control. On average, this can be expected to occur once in a 100-year period, which corresponds to an annual likelihood of 1 per cent. This means there is a 65 per cent likelihood of the event occurring in a 100-year period, i.e. the likelihood of the event occurring is *moderate*.

The assessment of likelihood is based on historical data and frequencies, as well as factors of significance to the simultaneity of forest fires, including meteorological data on the frequency of particularly dry years, so-called fire years. This provides a good knowledge base, and the uncertainty associated with the assessment of the likelihood of the adverse event is assessed as low.

The likelihood of this scenario playing out in these three precise locations has not been assessed.

Assessment of consequences

The social consequences of the given scenario are assessed as *small*. The scenario will primarily threaten the consequence type natural environment.

Life and health

Forest fires on this scale will most likely have an impact on life and health. In particular, strong variable winds constitute a major risk factor because fire crews and other intervention personnel operating close to the forest fires could be surrounded. Deaths can therefore not be excluded, but experience indicates that the number could be expected to be low, i.e. fewer than five people. The possibility of evacuation makes it fairly improbable that lives will be lost among the general population. The simultaneity of the fires requires helicopters and other resources to give priority to areas where the risk to life and health and material loss is considered greatest.

Fire and smoke injuries can also be expected. Smoke inhalation can produce both acute and chronic injuries. Intervention personnel, but also vulnerable groups in the affected areas in particular, for example people with respiratory disorders, will be subject to this. However, early evacuation can limit the extent of injuries in this latter group. The total number of injured people is estimated at between 20 and 100. The assessments are based on experience from previous forest fires, for example, the Froland fire.

The consequences in terms of fatalities have been assessed as very small, while for serious injuries and illness they have been assessed as small.

Nature and culture

It is expected that the total area of forest destroyed by fire will be approximately 100 km^2. For those areas concerned, this will mean significant changes to the environment, and several decades will pass before the normal state is restored. The long-term effects are primarily linked to changes in the ecological succession[69] and nutritional conditions for species.

[69] *A term used to describe changes to the composition of species in an area over time.*

Fires can have a profound impact on the faunal community, which includes birds, fish and mammals. The effects will essentially depend on the intensity and severity of the fires, and there are great variations from fire to fire.

The scenario would have medium consequences for the natural environment.

Economy

The economic losses from such an event are primarily linked to the loss of large areas of forest and timber, and buildings and infrastructure. Lengthy fire-fighting with both helicopter and manpower resources will also be costly. In addition, there will be reduced potential for the wilderness industry. The overall economic losses in such a scenario are assumed to be in the range of NOK 500 million, based on experience from previous forest fires. The indirect economic loss has not been assessed.

The economic consequences of the scenario would be small.

Societal stability

It is not expected that the forest fire scenario will cause any significant social unrest among the public in general. Forest fires are a known event with known consequences. However, the scope of the fires could cause anxiety among the public in other areas where there is an extreme risk of forest fire. Any perception of inadequate resources to fight the forest fires may result in weakened trust in the authorities and contribute to frustration in the population, and it is assumed that questions concerning the authorities' responsibility will come to the surface.

The scenario would have small social and psychological responses in the population.

The forest fire scenario will in various ways cause stresses for the inhabitants in the affected areas. People living in areas that are directly threatened by the fires will have to be evacuated. It may also be necessary to evacuate inhabitants in areas in which smoke and soot constitute a problem. It is assumed that up to 1,000 people will have to be evacuated from their homes for one or two days. Temporarily closed roads or short-term power outages will lead to some disruptions. Challenges related to unavailable roads and railways may arise.

The scenario's stress on daily life would be very small.

Assessment of uncertainty

The knowledge base for estimating likelihood of the scenario is regarded as good. A relatively large amount of historical data is available, with an empirical database going all the way back to 1900, as meteorological data. There is a great deal of knowledge about forest fires and there is wide-ranging empirical data. The estimate of the likelihood of the event occurring is sensitive to changes in the assumption that an extreme risk of forest fire occurs in three geographically unrelated counties at the same time. The consequences of the event are sensitive to changes in the wind and weather conditions, the type of forest in the affected areas, resources for firefighting and the degree of concurrency of the fires. Therefore, the sensitivity of the results is assessed as medium. Overall, the uncertainty associated with the assessments of likelihood and consequences in the scenarios has been assessed as *small*.

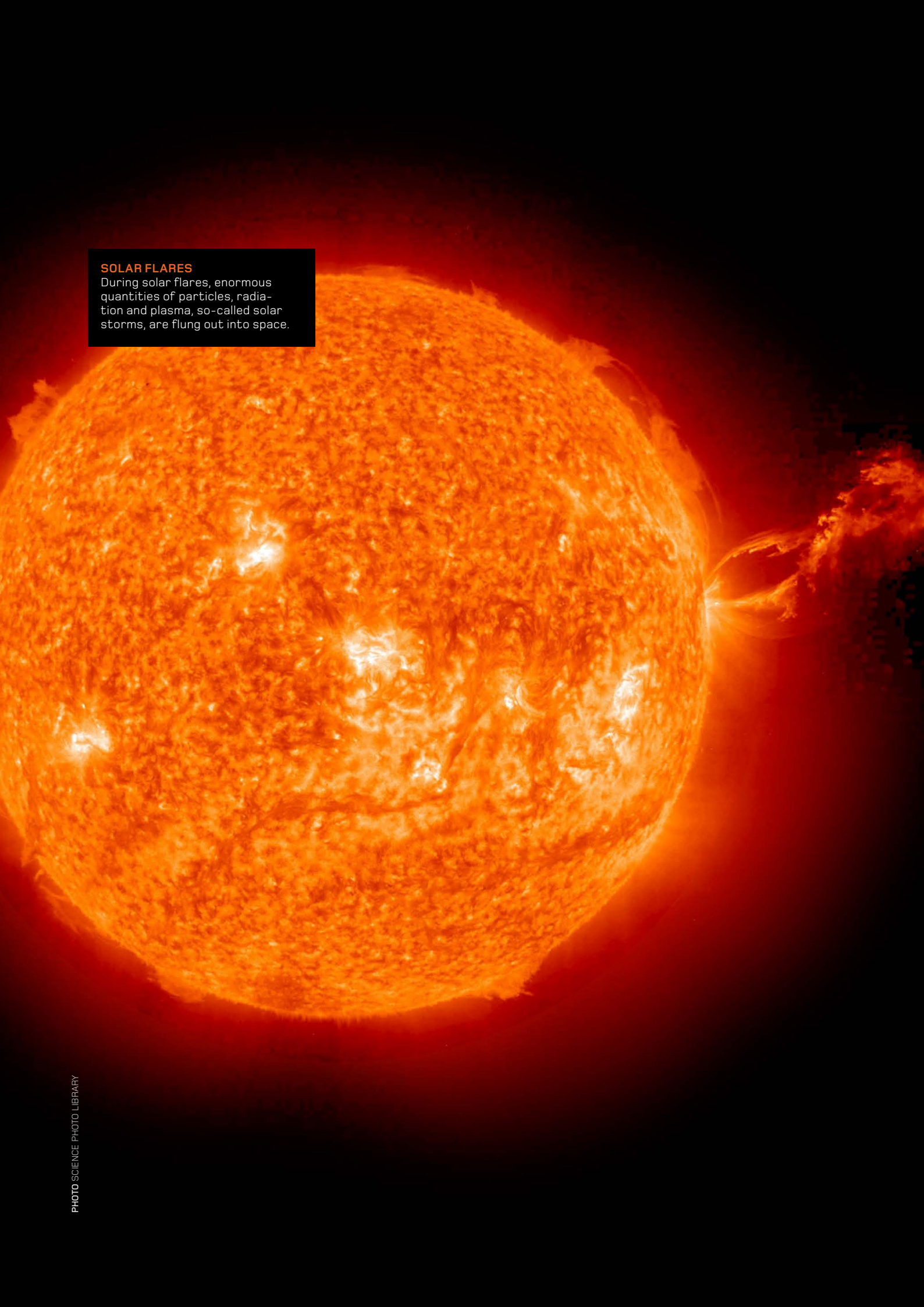
Possible measures

The following measures could reduce the likelihood and/or consequences of such events:

- Ensure information among the public about the risk of forest and wilderness fires and the ban on open fires that applies from 15 April to 15 September.
- Ensure good and accessible warning systems about the risk of forest fires and improve the forest fire hazard index from MET.
- Strengthen the cooperation between emergency preparedness actors and the forestry industry.
- Improve the competence of fire and rescue services on prevention and handling of forest and wilderness fires.
- Strengthen the helicopter preparedness and management support scheme for fire and rescue services.
- Ensure that the Norwegian Civil Defence obtains the skills and equipment to support the fire and rescue services in fighting forest fires.

TABLE 13. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario							The likelihood of this scenario occurring in these three precise locations has not been assessed.
Similar scenario on national basis				◎			65% likelihood of a similar scenario occurring in a 100-year period.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities	◎					Less than 5 fatalities as a direct or indirect consequence.
	People affected by serious injuries and illness		◎				20–100 injuries or ill people as a direct or indirect consequence.
Nature and culture	Long-term damage to the natural environment			◎			100 km² in total, significant environmental changes, several decades before restoration to normal state.
	Irreparable damage to the cultural environment						Not considered.
Economy	Direct economic losses		◎				Approximately NOK 500 million.
	Indirect economic losses						Not considered.
Societal stability	Social and psychological response		◎				The scope of the fires could cause anxiety among the public and any perception of inadequate resources to fight the forest fires may weaken trust in the authorities.
	Stress on daily life	◎					The evacuation of 1,000 inhabitants for 1 -2 days may be necessary, reduced mobility, disconnection of power supply.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES			◎				Small consequences overall.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY			◎				The uncertainty has been assessed as *small*.



SOLAR FLARES
During solar flares, enormous quantities of particles, radiation and plasma, so-called solar storms, are flung out into space.

PHOTO SCIENCE PHOTO LIBRARY

07

SPACE WEATHER

Background

The surface of the sun consists of plasma that can be regarded as a very hot electrically conducting gas. The gas flows continuously out from the sun, and together with electromagnetic radiation, this has an effect on the Earth and the area of outer space close to us in a series of processes with a joint designation called "space weather". At times violent explosions occur in the sun's atmosphere, known as "solar storms", in which large amounts of particles, radiation and gas with a magnetic field are ejected into space. The earth's magnetic field provides protection against solar storms, but this protection is weaker at the poles.[70] Space weather and solar storms are therefore a particularly topical factor for Norway since we are located in the far north.

The so-called Carrington Flare of 1859 is often referred to as the most powerful solar storm that has ever been experienced. The telegraph system was seriously affected - the operators received electric shocks - and fires arose in telegraph buildings as a consequence of the solar storm. A major solar storm was experienced in 1921 as well. This solar storm was not as powerful as the one in 1859, but involved the same type of consequences and challenges for the society of that time.

Several powerful solar storms over the past 20 to 50 years have meant disruption and cuts in the provision of telecommunications and power at irregular intervals and of varying duration. In 2003, there were many powerful electromagnetic storms on the sun, the so-called Halloween storms. Technical problems with satellites and satellite telephones were reported from several parts of the world. Because of problems with radio communications, international aviation on transatlantic and polar routes was reduced temporarily and traffic redirected, and notice was issued concerning increased radiation risks for aircraft passengers. In the USA, certain major power transformers were also damaged or destroyed, and large areas were left in the dark for some hours. Costs resulting from the solar storm were estimated as being at least NOK 4 billion. In Sweden, too, several thousand people lost power for a short period of time as a consequence of this storm.[71]

On 23 July 2012, there was a powerful plasma eruption on the sun, and the solar storm that followed is assumed to have been more powerful than the Carrington storm in 1859. If the outbreak had occurred one week earlier, the solar storm would have hit Earth's atmosphere according to estimates.[72]

[70] *NATO/EAPC, working paper 30 August 2011; Norwegian Space Centre (NRS); www.kriseinfo.no (14/12/2011).*
[71] *National Research Council of the National Academies (2008): Severe Space Weather Events–Understanding Societal and Economic Impacts, Workshop Report; US Department of Homeland Security, Federal Emergency Management Agency (FEMA), National Oceanic and Atmospheric Administration (NOAA), US Department of Commerce, Swedish Civil Contingencies Agency (MSB) (2010): Managing Critical Disasters in the Transatlantic Domain–The Case of a Geomagnetic Storm. Workshop Summery, February 23–24 February 2010.*
[72] *Baker, D. N. mfl. (2013): "A major solar eruptive event in July 2012: Defining extreme space weather scenarios"; Space Weather 11: 585-591.*

Risk

The designation "super storms" is used for 100- to 500-year storms. It is assumed that seriously powerful super storms like the one experienced in 1859 will occur, in statistical terms, every 500 years. Major solar storms of a size equivalent to the one of 1921 are assumed to occur once every 100 years.[73] The sun's activity is cyclical, reaching its maximum activity approximately every 11 years. It is assumed that large solar storms, such as the Halloween storms of 2003 may occur once during the course of every or every other 11-year cycle. Statistically, most geomagnetically active days occur in the waning part of the solar cycle. The sun is still in an active phase, even if the solar maximum in the current solar cycle has passed.[74]

Solar storms are categorised within three different types depending on the type of eruption on the sun:
1) As a rule eruptions send large volumes of *electromagnetic radiation* in the direction of the Earth. The radiation moves at the speed of light and reaches Earth within 8 minutes. The duration varies from a few minutes up to an hour.
2) During *proton showers* particles are ejected into space at very high speed and can reach Earth in 15–60 minutes. The duration varies from a few hours to several days.[75]
3) In addition, large clouds of plasma, known as CME[76], can be ejected into space. If this happens, *geomagnetic storms* are created, which release huge amounts of energy. Particles penetrate Earth's magnetic field and are conducted down over the polar areas. When the plasma clouds move towards Earth and interact with the magnetic field, normally after one to three days, it will usually be possible to see the Northern Lights. The more powerful the eruption on the sun, the further south the Northern Lights can be observed.

Neither electromagnetic radiation nor proton showers can injure humans, since we are protected by Earth's atmosphere, but the radiation can be very dangerous to people in space.[77] Proton showers can also be a potential health problem for aircraft crews who frequently fly over polar areas. The potential impact of a solar storm, for people or society, will essentially involve knock-on effects; for example, via the solar storm's effects on the power system, satellite communications and satellite navigation. If these systems are disrupted or fail altogether, solar storms could have a major impact on society.

If a geomagnetic storm is powerful enough, it can lead to drops in voltage over the power network. Experts in the USA have indicated that the impact could be enormous if a high number of large power transformers break down in many countries at the same time, principally because it can take up to a year to replace a transformer.[78] The vulnerability of the power systems varies from one country to another, however, depending on a number of factors such as soil conditions (conductivity), the grid and generation structure, technical solutions, use of earthing, etc.

Compared to the systems of other countries, the Norwegian system is considered to be relatively robust with regard to solar storms; due to technical solutions, decentralised production systems and fewer extremely long transmission lines, among other things. As opposed to the USA and Canada, for example, where large amounts of power are generated by a few large units that have to send the energy over long distances, power is generated in Norway from a larger number of smaller power stations with shorter distances to the consumers. The Norwegian power system has also been designed with some redundancy and to provide reconnection options at different voltage levels, to ensure that a power cut in one transformer does not necessarily lead to long-term cuts for end-users. Nevertheless, in the case of major solar storms, it is not possible to rule out that there will be short-term local or regional disruptions (a few hours) in the supply of power to end-users. Certain areas in Norway are more vulnerable than others since they have fewer local generation sources and lower network capacity in and out of the area.

Solar storms can also affect the reception of satellite navigation signals used for positioning, navigation and time information. GNSS (Global Navigation Satellite Systems)[79] offer positioning, speed and time signals. It is not unusual for the signals from systems of this type to be disrupted by solar storms for short periods of time. The scale of signal disruptions is dependent on the intensity and composition of the solar storm. Lengthy loss of satellite signals is fairly improbable.[80] For users, the effect of disruptions will depend on the availability of alternative systems. For most private users, solar storms will be non-problematic, but in crucial operations with strict requirements for performance, standby solutions will have to take over if GNSS cannot be used. Accurate positioning and navigation are used in the maritime sector, for example, including

[73] *U.S. Department of Homeland Security; Federal Emergency Management Agency (FEMA); NATO/EAPC, Working paper August 30 2011.*
[74] *Norwegian Space Centre (NRS); https://www.kartverket.no/kunnskap/posisjon-og-navigasjon/Romvar-og-posisjonstjenester/*
[75] *NATO/EAPC, Working paper, August 30 2011. 77 Coronal Mass Ejection.*
[76] *Coronal Mass Ejection.*
[77] *NATO/EAPC, Working paper, August 30 2011.*
[78] *National Research Council of the National Academies (2008): Severe Space Weather Events-Understanding Societal and Economic Impacts, Workshop Report.*
[79] *Joint designation for global satellite navigation systems. Today, there are two GNSS operational: the American GPS system and the Russian GLONASS system. A European satellite navigation system, Galileo, is planned to be operational from 2015. China is planning to complete the construction of the global BeiDou/COMPASS system in about 2020.*
[80] *Norwegian Space Centre (NRS).*

the oil and gas industry. Among other things, accurate time information is used in communications networks, in financial transactions and in the supply of power. The societal effect of critical operations using GNSS having to move over to standby solutions with potentially reduced efficiency, will be assessed specifically for the sector and operation.

Prevention and emergency preparedness

Solar storms cannot be prevented, but daily satellite observations of the sun provide us an 18 to 72 hour prior warning of when an eruption occurs on the sun until a geomagnetic storm hits Earth.[81] This provides public authorities, and other bodies with responsibility for important societal functions, with opportunities to implement previously prepared damage-reduction measures, if a powerful geomagnetic storm were to occur. However, it will not be possible to know how powerful the solar storm is going to be until one or two hours before it hits Earth.

As of today, there is no national arrangement for providing solar storm warnings. However, Norway is a participant in the ESA's[82] new monitoring programme of which a joint European space weather warning is an important element. Today, the Tromsø Geophysical Observatory carries out real-time services, and monitors the geomagnetism and disturbances in Earth's magnetic field. The Norwegian Mapping Authority entered into a collaborative agreement in 2011 with the German Aerospace Centre[83] to monitor the weather in the upper part of the atmosphere.[84]

There are several possibilities for preventing damage to the power system. The Norwegian power supply system is constantly monitored against all forms of operational disruption and to ensure balance within the power system. Immediate action at an operations centre might include controlled disconnection of parts of a facility or parts of the grid, in order to be able to connect it again undamaged.[85] The consequences of these measures for end-users will be anything from no noticeable changes to power outages of a certain duration. Disruptions to or loss of precise time for synchronisation and time stamping in the monitoring of the power grid could mean that fault location and fault correction will take a longer time.

For satellite navigation and accurate time information from satellites the access to several independent systems will contribute to reducing vulnerability when satellite systems fail. Knowledge of the possible impact of solar storms can contribute to reducing societal vulnerability. Among other things, the effect of providing a warning will depend on whether the authorities responsible for the sector and the users have the necessary knowledge of how the solar storm might affect their own systems, and therefore what measures ought to be implemented. With improved knowledge of solar storms and greater insight into their own systems, there will also be a greater possibility of securing redundant solutions and increased robustness in the systems, as well as to guarantee competent and efficient management during and after a major solar storm.

[81] *Ibid.*
[82] *Norway's membership in the European Space Agency (ESA) is administered by the Norwegian Space Centre.*
[83] *Deutsches Sentrum für Luft- und Raumfahrt.*
[84] *Norwegian Mapping Authority (www.statkart.no).*
[85] *In addition, reconfiguration, use of power line protection, counter purchases, export minimisation, disconnections, etc., are a few possible measures.*

SCENARIO

07.1 Solar Storm

A powerful solar storm would impact the power system and satellites, and in the worst case cause power outages over large areas as well as create problems for navigation, positioning, accurate time information and communication. To illustrate how serious the consequences of such an event can be, a risk analysis was conducted of a 100-year solar storm.

The risk analysis was conducted in the autumn of 2011 and was updated in 2018.

Course of events		
At the end of February, an unusually large and magnetically complex sunspot group appears on the sun. In the following days, several relatively strong explosions and outbreaks from the sunspot group are observed, which results in a sharp increase in the amount of UV and X-rays that hit the earth. The solar storm is the most powerful solar storm observed in modern times and causes power outages in North America and Northern Europe, disturbances in satellite signals, and radio communications breakdown.		
Time	**Scope**	**Similar events**
The solar storm hits in February and affects the Earth for a week.	Combination of three forms of solar storm (UV and X-ray radiation, proton shower and geomagnetic storm). The solar storm reaches the highest level on the space weather scale of NOAA.	• The Carrington storm in 1859. • The 100-year storm in 1921. • The Halloween storms in 2003.

Assessment of vulnerability

A powerful solar storm could impact the power system and satellites, and in the worst case cause power outages over large areas, as well as create problems for satellites that are important for navigation, positioning, accurate time information, communication and Earth observation.

Geomagnetically induced currents may overload power lines and in some cases damage transformers. However, the Norwegian power system is relatively robust to solar storms due to a decentralised production system and fewer long transmission lines. Nonetheless, some areas in Norway would be more vulnerable than others since they have fewer local plants and lower network capacity in and out of the area.

The loss of satellite services would impact the functionality of several critical societal functions, especially functions that depend on accurate time information from satellites. This includes financial services, telecommunications and the operation of critical ICT systems.

Assessment of likelihood

It is assumed that one large solar storm may occur during the course of the sun's 11-year cycle of activity. The likelihood of electromagnetic radiation,[86] a proton shower and a geomagnetic storm of the strength indicated occurring simultaneously is estimated to be once in a 100-year period, which results in an annual likelihood of 1 per cent and 65 per cent in a 100-year period. According to the categorisation in ACS, this corresponds to *moderate* likelihood.

Assessment of consequences

The consequences of the given scenario are assessed as *medium*. The impact of the scenario primarily involves knock-on effects in the form of disruptions to satellite signals and power outages. The uncertainty associated with the assessments of the different types of consequences varies from moderate to high.

Life and health

The scenario's impact on life and health is assessed as very low. However, injuries and accidents as a result of disruptions in critical services, such as power and electronic communications cannot be excluded as a consequence of the solar storm. Disturbances in the satellite signals may, for example, entail an increased risk of accidents in sectors that are dependent on precise signals, such as civil aviation and maritime sectors.

If other adverse events occur during the period in which the power supply and satellite signals are unstable, this could have a serious impact on life and health because of the reduced ability to get through to central emergency preparedness and emergency response services, and the reduced ability of the emergency services to communicate with one another.

The consequences for Life and health have been assessed as very small.

Economy

It is estimated that the direct economic losses due to the consequences of the scenario would be in the range of NOK 0.5-5 billion. The loss would mainly be linked to the costs associated with repairing any damage to power systems and Norwegian satellites. Satellites can be completely or partially damaged by high energy radiation,[87] which could represent billions of Norwegian kroner in losses. It is estimated that the indirect economic losses would be in the range of NOK 0.5–2 billion and linked to production and service losses in the areas affected by power outages. There will also be economic costs due to lost working hours and production losses within the affected sectors, such as the petroleum industry.

The direct and indirect economic losses have been assessed as medium.

[86] *Electromagnetic radiation is energy in the form of photons (light particles) emitted from a source of radiation at the speed of light. Electromagnetic radiation can be perceived as waves, and therefore it is also called electromagnetic waves.*

[87] *Gamma radiation (electromagnetic radiation from radioactive atomic nuclei) is often divided into two categories 'soft' (low energy) and 'hard' (high energy) radiation. University of Oslo, Faculty of Mathematics and Natural Sciences (www.mn.uio.no), 01/05/2013.*

Societal stability

Solar storms are a type of event that are assumed to be unknown and not very recognisable for the population, and we lack experience with a similar solar storm and any consequences it will have for our modern society. A powerful solar storm can thus create fear and uncertainty and social unrest in society.

The scenario is assumed to result in various effects on daily life for those who are directly affected by power outages and disturbances in other critical services and deliveries. It is assumed that several hundred thousand inhabitants will be affected by power outages for up to ten hours, and subsequently an unstable power supply for the entire day that the storm lasts. Loss of power will primarily affect societal functions without sufficient emergency power, vulnerable groups, such as the elderly and sick, and people who only have electric heating systems. However, the limited duration of the power cut in the scenario means that the situation does not become critical, and evacuation will probably not become necessary.

Disturbances in high-frequency (HF) communications bands[88] as a consequence of the solar storm will affect both air traffic and military users of such communications bands. Communications via low frequency signals will also be affected. It is assumed that more than 100,000 people will be unable to use ordinary electronic communications or public Internet-based services.

The disruptions to satellite signals will lead to imprecise time signals which again will be of significance for the implementation of financial transactions, control systems, telecommunications and operation of critical IT systems.[89] It is uncertain how long-term the effects of the disruptions may be.

Disruptions in satellite signals entail an increased risk of accidents in sectors in which the control systems depend on precise signals, such as industry, and the maritime and power sectors. As regards navigation, civil aviation will be affected to a small extent, linked to the fact that navigation systems within aviation are based on conventional (ground-based) systems that will not be affected by disruptions to satellite signals.

The scenario would result in a large social and psychological response among the public, and result in medium stress on daily life.

Assessment of uncertainty

As a phenomenon, relatively little is known about solar storms, even though there have been large solar storms (100-year storms) and so-called superstorms (100-to 500-year storms) earlier. In an increasingly technology-based society, the consequences would be far more serious than what was experienced in previous powerful solar storms. Nonetheless, there is great uncertainty about how a major solar storm would impact today's technology and infrastructure.

The uncertainty of the assessment of the likelihood of the adverse event and the knock-on effects has been assessed as medium. The uncertainty of the assessments of the different types of consequences varies from medium to large. The uncertainty of the assessments of the economic consequences in particular has been assessed as large. Overall, the uncertainty associated with the assessments has been assessed as *large*.

Possible measures

- Good routines for monitoring and warning of space weather are important for implementing consequence mitigating measures.
- Redundant systems, especially for accurate time information, would reduce the impact of satellites being damaged by solar storms.
- Enterprises, especially those that own critical infrastructure, should maintain an overview of whether, and to what extent, they are vulnerable to solar storms and the loss of satellite-based services. ◎

[88] *A distinction is made between low frequency, which covers the audible frequency range, and high frequency, which covers frequencies above the audible range. High frequency will be largely the same as radio frequency. For example, the Norwegian Armed Forces makes use of the HF band.*

[89] *Norwegian Space Centre (NRS). MSB 2014, "Vikten av var och när. Samhällets beroende av korrekt tids- och positionsangivelse."*

TABLE 14. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario				◎			65% likelihood of the event occurring in a 100-year period.
Transferability is not relevant.							
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities	◎					Less than 5 fatalities as an indirect consequence.
	People affected by serious injuries and illness	◎					Less than 20 injuries as an indirect consequence.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses			◎			NOK 0.5–2 billion linked to repairs of any damage to the power system and Norwegian-owned satellites.
	Indirect economic losses			◎			NOK 0.5–2 billion linked to production and service losses in the areas affected by power outages.
Societal stability	Social and psycho-logical response				◎		Unknown and not very recognisable event, lack of experience with a similar solar storm and its consequences, would cause fear, uncertainty and anxiety.
	Stress on daily life			◎			Several hundred thousand people will be affected by the power outage for up to ten hours, and subsequently an unstable power supply for the entire 24-hour period that the storm lasts. Disruptions to other critical services and deliveries.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES				◎			The social consequences have been assessed as medium.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY					◎		Overall, the uncertainty has been assessed as *large*.

EYJAFJALLAJÖKULL
Volcanic eruption at Eyjafjallajökull. Ash cloud hanging over the glacier.

PHOTO ORSOLYA HAARBERG / SAMPHOTO

08

VOLCANIC ACTIVITY

Background

The volcanic eruptions that can have consequences for Norway are generally those associated with volcanic activity in Iceland and the world's northernmost volcano, Beerenberg, on the Norwegian island of Jan Mayen. Beerenberg was regarded as extinct until unexpected eruptions took place in 1970 and in 1985, when a column of ash up to one kilometre high occurred. However, the only direct experience Norway has of being impacted by ash clouds are those that come from Icelandic volcanoes.

The explosive Eyjafjöll eruption in Iceland in 2010 resulted in violent clouds of volcanic ash and smoke that rose several kilometres into the sky. Unusually stable northerly and north-westerly winds then carried the ash to Norway and North-Western Europe. Ash clouds caused problems over most of Northern Europe. A total of 11,000 flights were cancelled and eight million passengers were affected.

There are numerous different types of volcanic eruption. The Eyjafjallajökull eruption of 2010 is an example of a phreato-magmatic eruption, which is often linked to eruptions in central Icelandic volcanoes that are completely or partially covered by ice. The combination of meltwater in the crater area and magma can lead to violent explosions and very high levels of ash production. A new eruption of the Katla volcano is often highlighted as a feared scenario with potentially enormous consequences as a result of very high levels of ash production.

The eruption in the Laki volcano system (Iceland) in 1783–84 is an example of a very large fissure eruption. The eruption continued for eight months and sent fountains of lava up to a height of at least 1,000 metres. The total volume of tephra[90] and lava was estimated at 0.4 km^3 and 15 km^3, respectively, and fountains of tephra and vapour reached heights of seven to thirteen kilometres. The eruption released 122 megatonnes of sulphur dioxide (SO_2). SO_2 is dissolved in small water droplets and forms microscopic airborne sulphate particles (aerosols[91]) that reflect the sun's radiation back into space, allowing less heat radiation to earth.

After the Laki eruption a haze of sulphate aerosols hung over Europe and North America for five months. 21 per cent of Iceland's population died as a result of the eruption and subsequent famine. The eruption also led to the cooling of the northern hemisphere and crop failures in Europe. A thick, sulphurous haze spread to Europe, and the United Kingdom and France reported several thousands of deaths due to respiratory poisoning.

[90] *Volcanic materials.*

[91] *When there is high pressure in the earth's crust, gas is dissolved in melted stone (magma). When the magma rises to the surface, the pressure diminishes and the gas is released. Sulphur dioxide and potentially other hazardous gases are released and become oxidised in water droplets, creating sulphuric acid among other things. They are transported in the air as microscopic sulphate particles (aerosols), which reflect solar radiation back into space, so that less heat radiation reaches the earth.*

In the middle of August 2014, the strongest earthquake since 1996 was registered in Iceland's largest volcano system, Bárðarbunga. The volcano lies under the ice of Europe's largest glacier (in volume) Vatnajökull. During the period before the eruption, more than 1,000 earthquakes were recorded a day, generally between 7–12 kilometres deep. This was the beginning of a more than 40-kilometre long fissure system that filled with magma. Over the autumn, there were larger lava eruptions in fissure zones on the north side of the volcano. The eruption did not lead to caldera collapse (the cone-shaped depression left after the 'plug' above the liquid magma in the depression sinks down), and therefore the eruption did not cause large quantities of ash. However, the eruption caused a lot of water vapour, carbon dioxide, sulphur, chlorine and fluoride-rich gases. Bárðarbunga released three to five times as much SO_2 every day as the total emissions of industry, shipping and other manmade activities in Europe. It has been calculated that over the period of the eruption, 35,000 tonnes of sulphurous gases were released every day. In comparison, Norway's emissions amount to approximately 17,000 tonnes per year. When the eruption ended in February 2015, the lava covered more than 85 km^2, and the amount of lava that had flowed out was calculated at 1.4 km^3. A full eruption below Vatnajökull that reaches the surface would have resulted in major flooding and enormous ash production, which could have resulted in a repetition of the Eyjafjöll eruption in 2010.

Risk

Norway can be affected by eruptions from several different volcanic systems. It is primarily an eruption from one of Iceland's approximately 30 different volcanic systems that could have an impact on Norway.

Volcanic eruptions are common on Iceland, with small eruptions every four or five years, while eruptions on the same scale as Eyjafjallajökull, for example, have a repetition interval of 10 to 20 years. The largest explosive eruptions, such as the major eruptions in Katla and Laki occur, on average, only at intervals of 500–1,000 years. Global warming could mean a rapid melting of glaciers. Where these cover volcanoes, the melting could mean increased volcanic activity due to the relief of pressure on the earth's crust.[92]

The scope of the ash distribution from an eruption on Iceland is dependent on meteorological conditions such as wind strength, wind direction and precipitation pattern. It is therefore difficult to predict the impact that an eruption on Iceland might have for Norway. The likelihood of aviation being affected to a greater or lesser degree as a consequence of a volcanic eruption is assessed as being very high (more than once in ten years).[93]

Volcanic eruptions can have health consequences for the Norwegian population in that the finest particles of the ash may be breathed in. In addition hazardous gases may be released depending on the materials contained in the magma. Sulphur dioxide, carbon dioxide and fluorine can occur in considerable volumes. The health effects can be irritation of the membranes in the eyes and nose and airways. The most exposed groups are people with pulmonary or cardiovascular diseases and children. The increase in carbon dioxide is only local and will not have any impact in Norway.

The impact of restrictions on air traffic will include immediate consequences that occur when the airspace is closed and also indirect consequences of importance to the economy and business. The most serious consequences of closed airspace are potential harm to patients and fatalities due to emergency patient transport by air ambulance and air ambulance helicopter not being possible.

In addition, the economic consequences of an eruption may be significant. This is largely due to the dependency of our era on air transport. Aviation operators and the travel industry, as well as subcontractors to these industries, could suffer considerable losses during a long-term closure of the airspace. A modern society is dependent on air traffic for a wide range of services, from the transport of people, goods and medicines to mail. It can take a long time to reorganise transport procedures. Indirect consequences escalate over time, and will become worse the longer the situation involving the disruption of air traffic lasts.

Volcanic eruptions involving ash and air pollution may mean increased vulnerability for various societal functions if other adverse events occur at the same time. For example will disruptions in transportation increase the vulnerability of functions and infrastructure that are dependent on the rapid

[92] *Directorate for Civil Protection and Emergency Planning (2010): Vulkanutbrudd – når og hvor kommer det neste? En naturvitenskapelig analyse i et norsk perspektiv. [Volcanic Eruptions – When and Where Will the Next One Come? A Scientific Analysis in a Norwegian Perspective.]*
[93] *The Geological Survey of Norway (NGU) and the Norwegian University of Science and Technology (NTNU).*

supply of spare parts. The likelihood of this vulnerability being of significance increases with the length and scope of the halting of air traffic. Volcanic eruption may lead to global cooling. This is linked to the spread of aerosols that reflect the sun's radiation back into space. This may contribute to cooling the earth by several degrees, and this effect may last from two to ten years.[94]

Prevention and emergency preparedness

As with other naturally triggered events, no volcanic eruption can be prevented. The next volcanic eruption that indirectly or directly affects us may be of a different nature and duration than the most recent ones we have experienced. Public authorities should be prepared for new eruptions that may challenge society in various ways.

After the Eyjafjallajökull eruption in 2010, the regulations for Norwegian civil aviation have been changed, and future eruptions involving ash clouds will probably have less of an impact on aviation than that experienced in 2010.[95] The new regulations mean that airspace will not be closed, but that risk zones and NOTAMs[96] will be established in which operators will be able to operate in at their own discretion and in compliance with their own procedures. The procedures must be approved by the aviation authorities in the country concerned. The scope of the impact depends, however, on the production of ash and hazardous gases in the volcanic eruption.

Many more airlines are now flying with aircrafts that are approved for flights in areas with medium concentrations of ash. Thus situations in which certain countries close their entire airspace can be avoided, and this would potentially result in greater flexibility in the regulation of air traffic during an event.

Whether, and possibly how far in advance, warning can be given of an eruption, depends on the type of volcano, recording of data and monitoring of seismic activity. Most volcanoes produce signs of an approaching eruption through small earth tremors and seismic activity. Warnings have been issued for all confirmed volcanic eruptions in Iceland since 1996 on the basis of seismic activity and some also by observing that the volcano is rising. One precondition to enable the planning of action to mitigate the consequences, is sufficient knowledge of volcanoes, ash column collapse and hazardous volcanic gases.

The Norwegian authorities are responsible for monitoring and providing reports concerning the Beerenberg volcano on Jan Mayen Island. A large eruption here may lead to huge volumes of ash, and, with strong westerly winds, the eruption may affect parts of Northern Norway. Responsible authorities must be prepared to be able to provide reports and meet the need for information in the event of large eruptions from this volcano. Administrative responsibility for the island of Jan Mayen lies with the County Governor of Nordland.

[94] *Directorate for Civil Protection and Emergency Planning (2010): Vulkanutbrudd - når og hvor kommer det neste? En naturvitenskapelig analyse i et norsk perspektiv. [Volcanic Eruptions - When and Where Will the Next One Come? A Scientific Analysis in a Norwegian Perspective.]*
[95] *Civil Aviation Authority – Norway.*
[96] *Notice to airmen. Information for flight crews concerning important circumstances.*

SCENARIO

08.1 Long-Term Volcanic Eruption in Iceland

A volcanic eruption throws out various types of emissions that pose a risk to people and the environment. Major eruptions release enormous quantities of toxic gases and ash particles that are flung into the stratosphere and dispersed across large areas by wind and precipitation. To illustrate how serious the consequences of such an event could be for Norway, a risk analysis has been conducted of a large, prolonged volcanic eruption in Iceland.

The risk analysis was conducted in the autumn of 2011 and was updated in 2018.

Course of events

For over a year, Icelandic geophysicists have recorded seismic signals deep in the Earth's crust in southeastern Iceland. Experts expect a major fissure eruption. In mid-April, the eruption starts when magma reacts with groundwater below ground, leading to an explosive eruption phase. Fine-grained ash, gases and aerosols are hurled into the stratosphere and the ash cloud eventually covers the whole of Northern Europe. During the course of the next five months, volcanic eruptions continue with varying intensity as new fissure zones open.

Time	Scope	Similar events
April–September.	14 km high eruption column with ash and gases 1,500 meter high fountains of lava 15 km3 tephra (volcanic materials) 125 megatonnes of sulphur dioxide	• The Laki eruption in Iceland in 1783, which caused many deaths and famine in Iceland, as well as the cooling of the northern hemisphere and crop failure in Europe. • The Eyjafjöll eruption in Iceland in 2010, which caused problems for air traffic over most of Northern Europe.

Assessment of vulnerability

Advance warnings have been issued for all recorded volcanic eruptions in Iceland since 1996, based on monitoring seismic activity or the landscape changing. What is far more difficult to warn about is what will happen during the actual eruption. Even though seismic activity indicates when an eruption is imminent with a large degree of likelihood, there will be a large degree of uncertainty regarding the character and scope of the actual eruption. When an eruption occurs, the Norwegian Meteorological Institute(MET) is responsible for forecasting how the ash will move and impact Norway.

Air traffic is vulnerable to volcanic ash, although some areas of airspace may be kept open depending on ash concentrations.

Early warning and continuously monitoring ash clouds and toxic gases make it possible to implement various consequence mitigation measures. The lessons learned from the Eyjafjallajökull eruption showed that emergency health services in Northern Norway were particularly vulnerable because they rely heavily on air transport. Airspace closures stop air ambulance flights. The emergency health service in Northern Norway was thus strengthened, both through reinforcement from health authorities in Southern Norway and by making military resources available.[97]

Parts of the population are critically dependent on special drugs and are therefore highly vulnerable where drugs are transported by air. Banning flights could, over time, also impact supplies of spare components for medical equipment, power plants and telecommunications networks.

Assessment of likelihood

During the course of the past 1,000 years, there have been four eruptions of the same type as the Laki eruption in Iceland. Two of the eruptions have been on an equivalent scale to the scenario defined. Because of the size of the eruption, it is assumed that Norway will be affected by the scenario regardless of the wind conditions.

Based on the eruption history, it is assumed that the scenario will occur approximately once every 500 years,[98] i.e. there is a 20 per cent likelihood that it will occur in the course of 100 years. In Analyses of Crisis Scenarios, this likelihood estimate falls under the category of *low* likelihood. The uncertainty associated with the assessment of the likelihood of the adverse event and the consequential events is assessed as moderate.

The analysed scenario is not the only possible serious volcanic eruption in Iceland. Eruptions in several other volcanoes could potentially have serious consequences for Norway.

Assessment of consequences

The overall consequences of the given scenario are assessed as *medium*. The scenario will primarily threaten Life and health, Economy and Societal stability.

Life and health

The greatest direct health hazard in Norway is associated with air pollution and the concentration of sulphur dioxide (SO_2). As a consequence of the eruption, the concentration in Norway will reach a level corresponding to the concentration in Southern Europe today. There is great uncertainty linked to studies of the health effects of SO_2, and this has consequently not been included in the assessment of the volcanic eruption's impact on life and health. Based on the modelled calculations, it is assumed that the concentration of fine fraction particles[99] reaching Norway will correspond to the current level of floating dust in Norwegian towns. Assessments of the scenario's healthrelated consequences have been made on this basis.[100] Current public health and health services are quite different from the situation when the Laki eruption took place in 1783, and the consequences cannot thus be compared directly.

It is assumed that exposure to fine fraction particles from the eruption might lead to the death of about 60 people, but there is a high level of uncertainty here. Exposure to ash particles will mean additional illnesses and complications for particularly vulnerable groups, such as children and people suffering from pulmonary or cardiovascular diseases. Among these, there will probably be an increased frequency of hospital admissions. It is assumed that about 60 people will require treatment in a hospital or will have long-term consequential symptoms or impaired general health over a prolonged period.

---

[97] *FFI report 2012/01319 "Askeskyen fra vulkanutbruddet på Island 2010–norsk krisehåndtering og noen erfaringer".*

[98] *Thordarson, T. og Larsen G. (2007): "Volcanism in Iceland in historical time: Volcano types, eruption styles and eruptive history", Journal of Geodynamics 43: 118-152.*

[99] *All particles with an aerodynamic diameter ranging from 2.5 to 0.1 micrometer (um). The aerodynamic diameter characterises aerosols and aerosol particles (airborne sulphate particles) and is used, for example, to indicate where in the airways the particles will stop*

[100] *Norwegian Public Health Institute, Norway's Institute of Transport Economics and Norway's Climate and Pollution Agency (2007): Helseeffekter av luftforurensning i byer og tettsteder i Norge. [Health Effects of Air Pollution in Towns and Villages in Norway.]*

The indirect impact on health depends on the extent to which the air ambulance service is affected, and whether this will imply serious harm to patients. The duration of the eruption is expected to affect the transport of pharmaceuticals via transatlantic routes.

The consequences with respect to fatalities would be medium, and small with respect to serious injuries and illness.

Nature and culture

One consequence of the volcanic eruption will be a reduction in sunlight getting through the ash/gas clouds. Since sunlight is just one of several critical factors for growth, the scenario is assumed not to lead to long-term damage to nature and the environment. With regard to crops, the climate in general and the water supply are probably just as crucial as sunlight. Because of large temperature variations in Norway from one day to another, there is no unambiguous connection between global cooling and the temperature in Norway in the short-term. However, the eruption will mean an increased likelihood of earlier frosts and a cold growing season. Together with less sunlight, therefore, it is likely to have some reduction in crop yields.

The consequences for the natural environment have been assessed as small.

Economy

It is estimated that the direct economic consequences would be very small and linked to the repair and maintenance of equipment and machinery that are vulnerable to volcanic ash. Reduced crops could also lead to higher food prices.

Because of loss of income, the eruption is assumed primarily to affect actors within Norwegian aviation and the travel industry. The scenario will also involve economic costs for the shipping industry. The impact on the petroleum industry is that it will not be possible to carry out sufficient staff changeovers. About 6,700 people are employed in oil and gas extraction at sea.[101] At times these will be affected as a consequence of disruption in air traffic. Due to the reduction in sunlight, it is assumed that agriculture will incur losses as a result of reduced yields from crops.

Assessments and calculations of economic losses following previous events come up with different figures. It is assumed that the scenario would result in significant economic losses, estimated to be in the range of NOK 10–20 billion.

The direct economic losses would be very small, while the indirect economic losses would be large.

Societal stability

Air pollution resulting from the eruption will affect vulnerable groups, such as children and people suffering from pulmonary or cardiovascular diseases. Based on experience with ash clouds, it is assumed that the population has expectations that the authorities and aviation actors are prepared to manage the consequences well. The longer the ash clouds create problems for aviation, the greater the reactions in the form of anxiety and frustration among the population.

The five-month-long volcanic eruption will be of significance to critical services and deliveries in large parts of Norwegian society. Closed airspace and disruptions in air traffic will mean increased vulnerability in crucial societal functions if other adverse events occur, due to disruptions in the transportation of important equipment, spare parts and manpower. In addition, it is assumed that many people will experience problems in connection with business and holiday travel.

The consequences in the area of social and psychological response have been assessed as large, and the stress on daily life has been assessed as medium.

Assessment of uncertainty

A lot of information and data from earlier eruptions are available, but we have no experience from such a large and long-lasting eruption in Iceland in modern times. The assessments are based on sector analyses, calculation models, analyses of air pollution in cities and towns, and experience from previous volcanic eruptions involving the spreading of ash in airspace. Assessments and calculations of the costs after previous events come up with different figures, and therefore the estimate for this scenario also ranges from NOK 10–20 billion. There were no major disagreements between the experts in the analysis work, with the exception of some differences in relation to assessments of the long-term damage to the natural world and the environment. The uncertainty associated with the knowledge base has been assessed as large.

[101] *Vatne, Erik (2018), "Sysselsetting i petroleumsvirksomhet 2017. Omfang og lokalisering av ansatte i oljeselskap og den spesialiserte leverandørindustrien." Samfunns- og næringslivsforskning AS, report 01/18.*

The consequences are sensitive to changes in the height of the eruption column, volume of ash and SO2 emissions, and the duration of the eruption. In addition to this, the wind and precipitation conditions are critical assumptions for the consequences. Consequential events such as power supply outages and problems with the telecommunications network and medical devices due to the ban on flights and failure to deliver critical spare parts would affect the consequences. Given this, the sensitivity of the results has been assessed as medium. Overall, the uncertainty has been assessed as *large*.

Possible measures

The ability to issue warnings and plan measures aimed at mitigating the consequences depend on knowing as much as possible about volcanoes, ash fallout and dangerous volcanic gases. The following may help to mitigate the consequences of such events:

- Contributing to research and international initiatives aimed at improving our knowledge about volcanic ash (including its effects on aircraft engines and further developing unmanned aircraft that can measure ash levels).
- Strengthening emergency preparedness planning for prolonged volcanic eruptions and ash cloud crises that last for a long time, paying special attention to the challenges associated with banning flights. ◎

GROUNDED BY ASH: There were signs of growing chaos at Sola Airport on 24 May 2011 due to the volcanic eruption in Iceland and the subsequent ash cloud.

PHOTO NTB SCANPIX/TOMMY ELLINGSEN

TABLE 15. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario			◎				20% likelihood of the event occurring in a 100-year period
Similar events on a national basis.				◎			40% likelihood of a similar scenario occurring in a 100-year period.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities			◎			About 60 direct fatalities as a result of exposure to fine fraction particles.
	People affected by serious injuries and illness		◎				About 60 persons requiring hospital treatment or with impaired general health.
Nature and culture	Long-term damage to the natural environment	◎					Possible earlier frost and or cold growing season with reduced yields from crops.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses	◎					Insignificant consequences.
	Indirect economic losses					◎	NOK 10–20 billion.
Societal stability	Social and psycho-logical response				◎		Due to the long duration of the event people will react with anxiety and frus-tration
	Stress on daily life			◎			Major consequences for the air trans-port of people and cargo, shortage of input factors for vtal societal functions
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES				◎			Moderate consequences overall.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY					◎		The uncertainty has been assessed as *large*.

EARTHQUAKE IN ITALY IN 2009: Earthquake in L'Aquila in the Abruzzo region of Italy. Rescue crews search for survivors and bodies. The earthquake had a magnitude of 6.3 and left 30,000 people homeless, 2,000 injured and around 280 dead.

PHOTO LUCA KLEVE-RUUD / SAMPHOTO

09

EARTHQUAKE

Background[102]

The crust of the earth is made up of a number of continental plates that are in motion. The areas that are geographically located near the boundaries and meeting points between the continental plates are those most exposed to earthquakes.

The movement of the plates creates stresses in the crust of the earth. The plates either collide, slide past each other, or move away from each other. Earthquakes occur when the stresses become too great and cause a sudden break in the Earth's crust. The energy is unleashed in the form of seismic waves. These waves spread outwards through the ground in all directions simultaneously and can vary in strength from imperceptible to extremely strong shock waves that cause intense shaking and do major damage to buildings and infrastructure.

Norway lies far from the plate boundary between the American and the Eurasian plates, but compressional stress from the plate boundary along the Mid-Atlantic Ridge have nonetheless proved to be an important factor for earthquakes far into the plate. The second stress generating factor is the elevation of Scandinavia after the deglaciation (glacioisostatic stresses). As a third factor, in coastal areas stresses will particularly be generated as a consequence of the simultaneous elevation of land and sedimentation and land subsidence at sea. The crust is thereby especially "bent" in coastal areas, which further increases stresses in the crust precisely in the coastal zones.

Measurement of earthquakes

The absolute strength of an earthquake is described using magnitude. There are several scales of measurement that have been and are in use. The reason for the many scales is that the dynamics of earthquake energy are so gigantic from the tiniest to the greatest quakes, and previously it was not possible to use the same scale for all quakes. At the present time, Moment Magnitude (Mw) is used more and more exclusively, which is a linear logarithmic scale that is proportional to seismic moment. For all practical purposes, the Richter Magnitude and Ms Magnitude are synonymous with Moment Magnitude. Previously, the two magnitudes covered different parts of the scale.

The use of Richter's scale is the traditional method of quantifying the strenght of earthquakes. The Richter scale is logarithmic. This means that an increase of one unit on the scale represents an increase of ten in the intensity of the Earth movement measured, and an approximately 32 times increase in the amount of energy released. The table below shows how often earthquakes of various strengths occur in the world:

[102] *Presentation of the risk area Earthquake is based on collated information from the websites of and input from the Department of Earth Science (University of Bergen), NORSAR, Geological Survey of Norway (NGU), Norwegian Geotechnical Institute (NGI), Standards Norway, County Governor in Hordaland and others.*

Description	Magnitude	Average number per year
Disastrous	8 or higher	1
Very Strong	7–7.9	18
Strong	6–6.9	120
Moderate	5–5.9	800
Weak	4–4.9	6 200
Small	3–3.9	49 000
Very Small	Less than 3	Magnitude 2–3: approx. 365,000 Magnitude 1–2: approx. 3,000,000

Events

Norway experiences the highest level of earthquake activity in Europe north of the Alps. The majority are weak, but some of these quakes are so strong that they are felt by people. A few larger quakes have been documented, some have even caused damage to buildings and infrastructure, and it can happen again:

- 1819 in Mo i Rana: This earthquake was later calculated to have a strength of M 5.8. A number of landslides were observed, and the shock waves were described as so strong that people and animals could not remain standing upright, but fell over. The damage to buildings from this earthquake is not known.
- 1904 at Hvaler, Oslo Fjord: This earthquake (M 5.4) caused damage in several places northward along the Oslo Fjord all the way up to Oslo (Christiania), and far from the center of the quake. Many buildings were damaged, but did not collapse, and there was near panic among the population in several places.
- 2008 in Stor Fjord west of Longyearbyen, Svalbard: This quake (M 6,1/6.2) is the strongest in recent times. The hypocenter was in the sea far from people and thus did not cause any damage. What is interesting in this context is that the type of tectonics in this area are not significantly different from Western Norway, and thus indicate the possibility of a similar earthquake occurring along the Øygarden fault.

There are examples of similarly strong earthquakes that have had disastrous consequences, for example the quake in L'Aguila in Italy in 2009 (M 6.4) in which 309 people lost their lives. In August 2016, a new strong earthquake (M 6.2) occurred in Italy, this time in Appeninnene, 130 kilometres northeast of Rome. The actual main earthquake occurred in the middle of the night and was followed by around 40 powerful aftershocks. The earthquake caused outbreaks of panic in Rome. There were a total of 299 fatalities. The village of Amatrice was hit hardest and more than three years after the earthquake the village still lies in ruins.

Risk

We do not know of an earthquake in Norway that has caused fatalities. Even though the likelihood is low, major earthquakes can occur nonetheless and the consequences can be serious, primarily in densely populated areas with building constructions that are not sufficiently robust. The size of the earthquake is often less relevant than where it is located in relation to population centres. The time of day also affects the consequences.

It is not the earthquake itself that causes loss of life, but rather the secondary effects of the quake. Powerful shock waves can cause houses, roads and bridges to collapse, and the occurrence of landslides, dam bursts and fires.

While wooden structures generally have a high tolerance to shock waves, older brick buildings, particularly apartment houses from the end of the 1800s, are vulnerable due to weaknesses in the structural design. Apartment building developments from the 1960–70s were constructed with prefabricated concrete elements as floor slabs, which are vulnerable to sideways movements. New building designs can also be vulnurable to earthquake damage if earthquake loads for the buildings are not taken into account.

If buildings are located on clay deposits that amplify the seismic waves of an earthquake and consequently could amplify the damages from quakes. Uncompacted materials (sand etc.) that have been saturated by groundwater may be exposed to so-called liquefaction, that causes otherwise solid soil to behave temporarily as viscous liquid, and give way. Liquefaction will also lead to buried tanks, pipelines and the like floating up to the surface, since they are lighter than the liquid ground.

The statistical material we possess is not comprehensive enough to be able to carry out a detailed calculation of the likelihood of a major earthquake in Norway. Estimates for the return period for an earthquake with a strength of 6.5 or greater are therefore encumbered with very high uncertainty.

The areas with the most earthquake activity on mainland Norway are:

- Southern Hordaland, in the vicinity of Sunnhordaland and Hardanger.
- Northern Rogaland, in the vicinity of Ryfylke and Haugalandet.
- The coast along Møre og Romsdal.
- Around the Oslo Fjord.
- Major portions of Nordland.

Prevention and emergency preparedness

Monitoring of earthquake activity in Norway is undertaken by the Norwegian National Seismic Network (NNSN) which is operated by the Institute for Geological Science at the University of Bergen along with NORSAR (Norwegian Seismic Array), which contributes data from its seismic monitoring stations. NNSN consists of 33 seismic stations on the Norwegian mainland, as well as Svalbard and Jan Mayen.

Earthquakes can essentially not be predicted. No one has unambiguously documented predictions of a larger earthquake before it occurred. Damage-limiting measures are based on statistical calculations of shock waves over a period of time, and the use of these calculations to provide regulations for how much buildings should tolerate.

Preventive measures against adverse consequences of earthquakes are primarily connected to the use of the standards specifying how structural design should be conducted within the European Union – the so-called Eurocodes. Eurocode 8: Design of structures for earthquake resistance has been implemented in Norway as of March 2010. The authorities are obligated to adapt national regulations in the field of construction so that the Eurocodes can be put to use.

The technical foundation for adaptation of the regulations in Norway is based on a seismic zoning map completed in 1998. An important measure in further preventive work is to make use of newer data, as well as new methods for preparing updated seismic maps of Norway as a basis for the national Eurocode 8 Annex. A careful analysis can then be carried out of how various loose materials are affected by earthquake waves, and possibly include a mapping of the vulnerability of buildings and infrastructure, especially for older buildings in the larger cities.

For the Norwegian continental shelf there are special regulations, and since the mid-1980s offshore structures should be designed to tolerate earthquake stresses.

SCENARIO

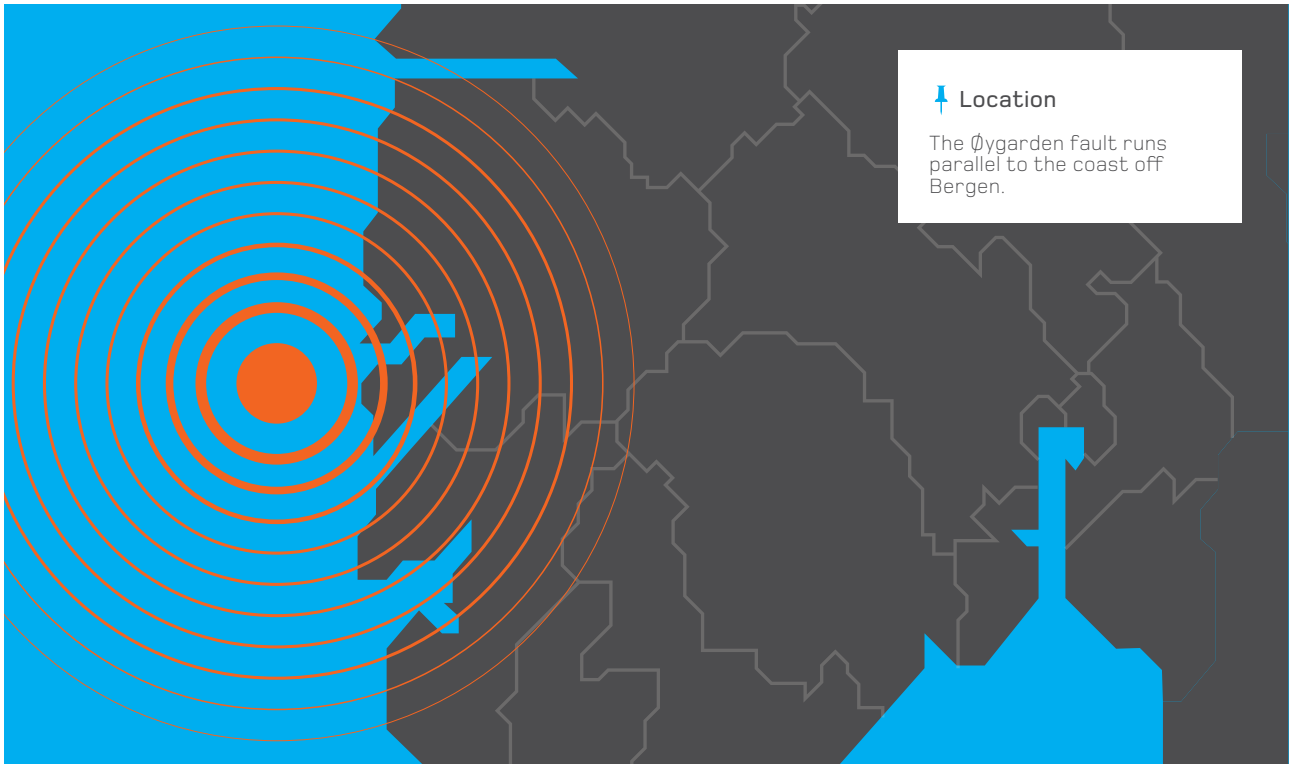
09.1 Earthquake in a city

Norway experiences the highest level of earthquake activity in Europe north of the Alps. Most of the earthquakes are barely noticeable and no fatal earthquakes have been confirmed. However, historically, there have been earthquakes that have damaged buildings and caused panic among the public. Even though the likelihood of a strong earthquake is low, it is still a possibility. In 2014, an analysis was conducted of a scenario in which a major earthquake strikes the Bergen region. The analysis was reviewed and revised in 2018. The analysis is documented in a separately published report.[103]

Course of events

A magnitude 6.5 earthquake occurs along the Øygarden fault which extends parallel to the coast off Bergen. The earthquake occurs without warning and causes major tremors in Bergen municipality, home to approximately 280,000 inhabitants. In the city, various building structures, both historic and modern, are exposed to strong tremors. The road network and other infrastructure, such as the power and drinking water supply networks, are subjected to tremors. The whole of Bergen municipality is affected and a large number of sites scattered around the municipality suffer simultaneous damage. The consequential events would initially include landslides and falling rocks, partial failure of the power supply, unstable electronic communications and partial disruption of the drinking water supply. Several other densely populated municipalities in the region lie within the danger zone.

Time	Scope	Similar events
Earthquake strikes in the middle of the day on a weekday in January.	The earthquake has a magnitude of 6.5 and creates strong shock waves in the Bergen area. It lasts for 45 seconds, and the strongest shock waves last for 25 seconds. Danger of aftershocks for several months, and in the worst case several years.	• 1904 at Hvaler, Oslo Fjord, with a strength of M 5.4. The earthquake caused damage to several sites north along the Oslo Fjord, all the way to Oslo. Many buildings were damaged, but did not collapse. • 2008 in the Stor Fjord west of Longyearbyen, Svalbard, with a strength of M 6.1 / 6.2. It was at sea, far from people, and thus did not cause any damage. • 2011 in Christchurch, New Zealand, with a strength of M 6.3. The costs after the earthquake were approximately NOK 130 billion.



[103] *Report "Risikoanalyse av jordskjelv i by", DSB, 2014.*

Assessment of vulnerability

Much of the vulnerability in a major urban area depends on the ability of buildings to withstand strong tremors. Brick buildings built at the end of the 1800s and multi-storey buildings built in the 1960s and 1970s are both examples of building types that have been identified as vulnerable to powerful earthquakes.

The vulnerability of critical infrastructure will impact the emergency response and functional capability of crisis management, and therefore the consequences for life and health, primarily. Damaged infrastructure could hinder accessibility, lengthen response time of rescue crews, prevent or delay medical treatment, etc.

The event would represent a major challenge to the community's emergency preparedness resources. A large number of collapsed buildings, a large number of simultaneous damage sites and reduced accessibility would make rescue efforts very difficult.

Unmapped local geological ground conditions such as clay deposits and loose materials could significantly increase the vulnerability.

Assessment of likelihood

As of today there is no good method for predicting large earthquakes. The Gutenberg-Richter law describes the quantitative distribution among large and small earthquakes, and is often used to estimate the frequency or return period for large earthquakes. The return period for a large earthquake in the Øygard fault can be very roughly estimated from a Gutenberg-Richter distribution of observed earthquakes. The occurrence of larger earthquakes in the coastal waters beyond Western Norway has been known for the past 50 years, but most larger quakes (M 5.0 +) have been far from the coast. Estimates for the return period for an earthquake of M 6.5 or greater are therefore encumbered with very high uncertainty.

For this specific scenario, the estimated return period is between 5,000 and 10,000 years, i.e. there is a 0.01–0.05 per cent likelihood that it will occur in a one-year period. The likelihood of this event occurring in a 100-year period is 3 per cent. In Analyses of Crisis Scenarios, this corresponds to *very low* likelihood.

There are several earthquake-prone areas in Norway. In addition to the coastline along the Øygarden fault, there are areas in Nordland and the Oslo Fjord area. A study of the whole of Norway south of Trondheim in 1998 calculated a return period of 1,110 years for earthquakes with a magnitude greater than or equal to 6.5.[104] This included the Oslo Fjord area. There are two or three areas outside of the Bergen region where a scenario with similar consequences could occur. This results in a 10% likelihood of a magnitude 6.5 earthquake with similar consequences occurring in a 100-year period, which is categorised as *low* likelihood.

Assessment of consequences

The societal consequences of the scenario described have been assessed as *very large*. The events in the scenario would primarily threaten the societal assets Life and health, Nature and culture, Economy, and Societal stability. Only the consequences of the main earthquake have been assessed. Any consequences caused in the aftershock period have not been included in the assessment.

Life and health

The number of fatalities as a result of the earthquake is estimated at more than 300. The majority of the fatalities are due to building collapse.

At the center of Bergen there are approximately 880 old brick apartment houses built at the end of the 1800s, in which all the internal structures are made of wood. These are buildings of three to five storeys. It is estimated that one out of every 30 of these buildings will collapse, in other words around 30 buildings of this type. It is assumed that on average 16 people live in each building. It is further assumed that half (240) of the residents will be at home when the earthquake occurs, and that half of them (120) perish. Outside of the city centre there are approximately 40 high-rise apartment buildings from the 1960-70s, of ten to twelve storeys. It is estimated that 10 per cent of these will collapse, i.e. four apartment buildings with a total of 640 residents. It is further assumed that half (320) of the residents will be at home when the earthquake occurs, and that half of them (160) will perish.

[104] *NORSAR and NGI (1998): Seismic zonation for Norway. Report prepared for the Norwegian Council of Building Standardization (Standard Norge).*

Some people will perish in other buildings that collapse, and in accidents that arise when the earthquake occurs. This last group will include pedestrians, cyclists, motorists in the vicinity of buildings that collapse, people who are hit by landslides or falling rocks, or are involved in other accidents.

It is assumed that the earthquake will result in approximately 500 seriously injured persons. The majority of those who survive in collapsed buildings will suffer from serious injuries. Most of them will need emergency medical treatment. Damaged/destroyed medical equipment, reduced ambulance accessibility and time-consuming searches for survivors in collapsed buildings will result in delayed medical treatment, which for many of the injured people will mean deterioration of health conditions.

It is assumed that many survivors in collapsed buildings will experience psychological distress such as anxiety and post-traumatic stress disorder, but that only a few will have longterm effects. Many people who witnessed buildings collapse, and who live in similar buildings, also are assumed to suffer from psychological stress.

The consequences with respect to fatalities would be very large, and large with respect to serious injuries and illness.

Nature and culture

The scenario analysed is assumed to have minimal long term effects on the natural environment. It is assumed that the types of nature that are affected by landslides will be restored in the course of 10 years. Some minor events of acute pollution are assumed to occur. Acute pollution attributed to a potential rupture in the subsea pipeline systems connected to the major oil and gas installations at Ågotnes, Sture, Kollsnes and Mongstad is not very likely. Today's pipeline systems are designed to withstand shocks of earthquakes and have several shut-off valve systems at both ends and along the pipelines.

It is assumed that several listed buildings will collapse or suffer irreparable damage. This primarily applies to the brick buildings in and around the city hall area, such as the Old City Hall, Hagerupsgården/Stiftsgården, Gamle Bergen main fire station, the Old Courthouse and the Magistrate Building.

In general, it is expected that wooden buildings will tolerate the shock waves, but may incur minor damages. This also applies to the unique cultural environment that the old Hanseatic wooden buildings at Bryggen represent.

The consequences with respect to long-term damage to the natural environment have been assessed as very small, and very large when it comes to irreversible damage to the cultural environment.

Economy

The direct economic losses are assumed to be very large due to a large number of collapsed buildings and extensive damage to other buildings, infrastructure and inventory, machines, equipment, etc.

To rebuild the 30 brick apartment houses that are assumed to collapse will cost around NOK 7.5 billion. The reconstruction costs related to the 4 high-rise buildings are assumed to be around NOK 10 billion. In addition, there will be major repair and replacement and compensation costs caused by material damages. This will include all construction types and buildings such as private homes, apartment buildings, office buildings, industrial buildings, etc. It is estimated that costs related to buildings alone will be at least NOK 25 billion.

Damage to infrastructure will be a major cost driver, particularly damage to the road system, also caused by any landslides. Regarding power supply, the economic consequences are primarily assumed to be comprised of repair costs related damaged power transformer stations and substations. Costs related to damaged infrastructure are estimated to NOK 5 billion. Damage to furnishings and fittings, equipment (including technical medical equipment), machinery etc. are assumed to be very extensive. Some degree of internal damage is assumed to incur to most buildings. It is assumed that 10 per cent of all furnishings and fittings will be damaged. Overall, the costs regarding damages are estimated at NOK 5 billion.

Primarely, the indirect economic losses will encapsulate losses of income, including tourism, decline in production and disruptions to business operations as a consequence of material damages to commercial buildings, reduced accessibility, cancellation of (cruise)ships calling, costs of delays and decline in consumption. Expenses associated with the evacuation of people from a large number of buildings and the acquisition of new housing for a large number of households for a longer period of time will also comprise a category of indirect losses, which is estimated at NOK 1–2 billion.

The direct economic consequences have been assessed as very large, and the indirect economic consequences as medium.

Societal stability

The consequences of earthquakes are known, but the total picture of collapsed buildings and a large number of fatalities and serious injuries, possible landslides, destruction of infrastructure, extensive damage to furnishings and fittings and the fact that one literally loses his footing, have not been experienced by today's population. The event will be a shocking experience and will cause alarm and fear of aftershocks in the population.

An earthquake occurs without warning, lasts for a short period, and there is a lack of possibility to escape the event. People who are outdoors will initially be safe or have a greater chance to escape the dangers, while people who are in high-rise and apartment buildings will have great difficulty getting to safety, compared to people in detached houses. Vulnerable groups such as children, the sick or the elderly are especially exposed, and have a great need for assistance in the emergency phase.

There will be high expectations that the authorities manage such a crisis, both with regard to the rescue response, emergency assistance, and in crisis communication with the population. It is assumed that failure to meet these expectations will lead to distrust of the authorities and anger in an early phases of crisis management. Crisis management will be very complex and challenging, and the emergency services will be confronted with chaos and many simultaneous, and widely-spread damage sites, reduced accessibility and major technical challenges associated with search and rescue in collapsed buildings. This will affect the possibility of managing the event at an early stage, and many people are assumed to experience a high sense of helplessness and a lack of information.

The scope and consequences of the event would be confined to the earthquake-stricken area, where the quake also would stir the strongest reactions in the population. It is assumed that the population elsewhere in the country would be shocked at the scope of the event, but not directly impacted by the event, unless they have close relatives who is affected.

Overall, it is assumed that the characteristics of the event would result in a large social and psychological response among the public.

The scenario will entail major stresses on daily life. In the first instance this is due to delays in transport of people and goods, failures in power supply, and a great need for evacuation. The scenario occurs in the winter, and if the quake affects around half of the transformer stations involved in supplying the city, initially it will result in a power deficit that will lead to rationing. The situation will be worst during the initial hours after the quake. Then large parts of the city may be without power.

It is assumed that approximately 500 persons will be evacuated for more than one month since their home or apartment has been destroyed. In addition, it will be necessary to evacuate approximately 20,000 persons for two to three days from the buildings that incurred major damage until the extent of the damage and safety can be assessed. Primarily, unstable electronic communications services will be due to network overload. The transport of people and goods will be affected, and substantial delays on the road network are assumed for up to one week.

Overall, it is assumed that the characteristics of the event would cause a large amount on stress on daily life.

Assessment of uncertainty

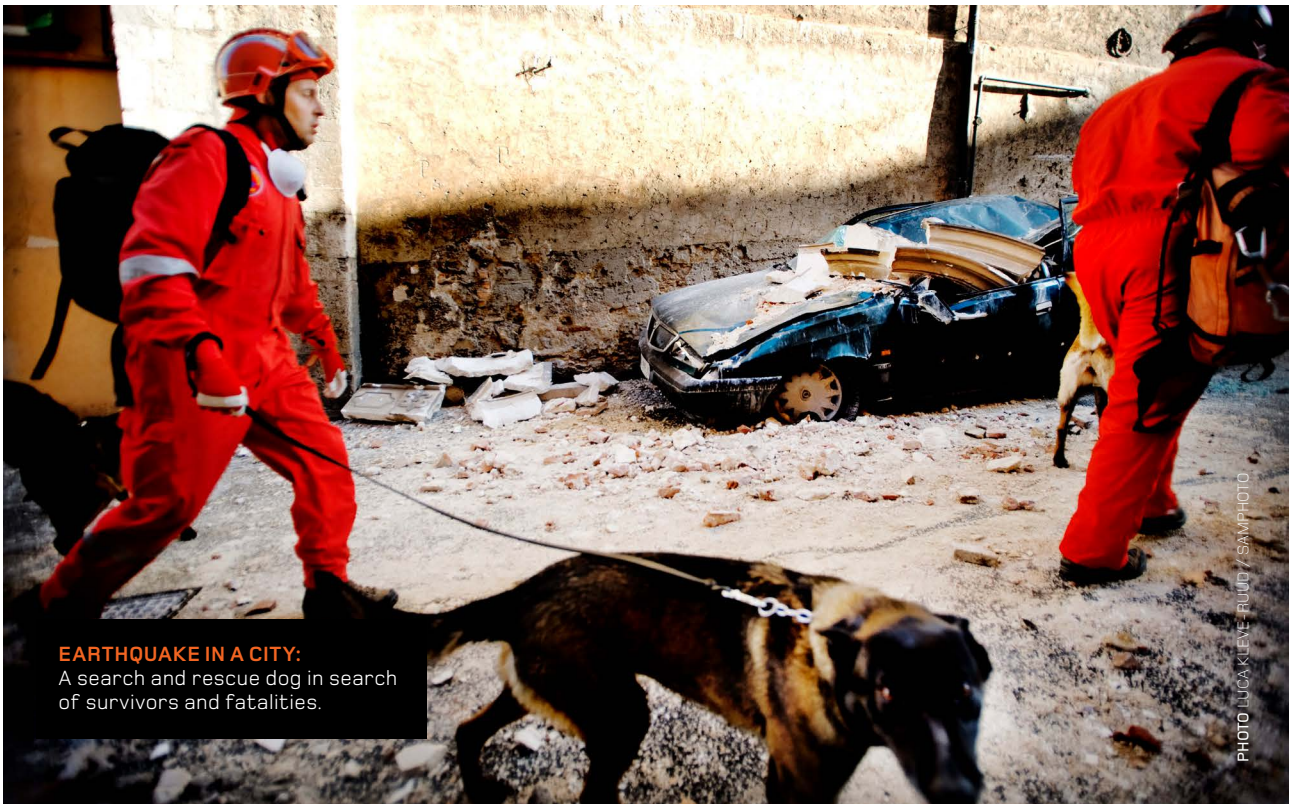
In general, a lot of data about earthquakes is available and there is a broad, international geoscientific research community. Globally, there is also broad experience of major earthquakes that have struck urban communities, although there is nonetheless uncertainty about how a major earthquake would affect buildings and infrastructure in today's Norwegian society. There were no major disagreements between the experts who contributed to the analysis.

Small changes in relation to distance to the epicentre of the earthquake, the ability of existing buildings to withstand seismic impact, local ground conditions, time of the (day versus night), season of the year and consequential events such as landslides could make a big difference to the consequences. The consequences are also sensitive to simultaneous events such as storms, flooding, power outages or major accidents, which would make crisis management substantially more complicated due to limited emergency preparedness resources available. The uncertainty associated with the results of the analysis has therefore been assessed as *large*.

Possible measures

The results of the analysis indicate that it is first and foremost the ability of buildings and infrastructure to withstand seismic impact that would affect the scope of consequences. Preventive measures would necessarily have to be based on more detailed analyses, meaning that:

- Relevant academic and professional institutions should learn more about what the consequences of a major earthquake in Norway would be with respect to buildings and critical infrastructure, including:
  - using more recent data from the period after the earthquake study from 1998 and new methods for producing stress maps[105] for the whole of Norway as a basis for the national supplement to Eurocode 8.[106]
  - using an earthquake scenario to assess the consequences for critical infrastructure and buildings.



EARTHQUAKE IN A CITY:
A search and rescue dog in search of survivors and fatalities.

PHOTO LUCA KIEVE - RUDD / SAMFOTO

[105] *A stress map indicates which seismic impact different structures must be able to withstand.*
[106] *Eurocode 8 is a Norwegian and European building standard that specifies requirements for the design of constructions for seismic impact.*

TABLE 16. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario		◎					3% likelihood of the event occurring in a 100-year period
Similar events on a national basis			◎				10% likelihood in a 100-year period.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities					◎	More than 300 dead as a result of collapsed buildings and landslides /falling rocks or accidents.
	People affected by serious injuries and illness				◎		Approximately 500 seriously injured as a direct result of the earthquake and delayed medical treatment.
Nature and culture	Long-term damage to the natural environment	◎					Damage from landslides, but restoration of the nature within 10 years.
	Irreparable damage to the cultural environment					◎	Many protected cultural artefacts will be lost.
Economy	Direct economic losses					◎	Reconstruction, repair and compensation costs of at least NOK 35 billion.
	Indirect economic losses			◎			Loss of income, costs of delays, decline in production, reduced tourism and trade, costs of evacuation etc. amount to a combined loss of NOK 1–2 billion.
Societal stability	Social and psychological response				◎		Unexpected, shocking event. Many deaths and injuries and major destruction create a sense of helplessness and fear. Extremely demanding crisis management.
	Stress on daily life				◎		Delays on the road network, power outage and rationing measures, local loss of water and extensive evacuation.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES						◎	Very high consequences overall.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY					◎		The uncertainty has been assessed as *large*.

MONGSTAD PRODUCTION PLANT: Crude oil terminal, oil refinery and NGL processing plant. One of the largest oil and product ports in Europe.

PHOTO MARIT HOMMEDAL / SCANPIX

10

CHEMICAL AND EXPLOSIVE INCIDENTS

Background

A number of chemicals and explosives with potentially damaging effects are used in manufacturing processes in industry and other parts of the business sector. The substances can be toxic, flammable and explosive, and represent a risk to life and health, the environment and material assets. Events can be triggered by use, production, storage or transport, and may occur due to safety system failures. Intentional acts such as terrorism or sabotage cannot be excluded.

Incidents involving chemicals or explosives may be unpredictable and are often characterised by great uncertainty. There will therefore be a huge demand for information among the public. On 5 April 2000, a catastrophe was just a few minutes away. A train with two tank wagons loaded with propane collided with a stationary train in Lillestrøm station area. There was a propane leak that caught fire. A powerful gas explosion was imminent. Such an explosion would have caused a significant number of fatalities and could have left large parts of the city centre of Lillestrøm in ruins. 2,000 inhabitants were evacuated during the incident.[107]

On 24 May 2007, a tank of petroleum products containing sulphur compounds exploded on the site of the company Vest Tank in Sløvåg in Gulen municipality in Ytre Sogn. The explosion was violent and also led to a nearby tank containing oil products catching fire. No one was physically hurt in the accident, but many in the community experienced discomfort, nausea, a sore throat and great anxiety in its aftermath. The health authorities' investigation nonetheless concluded that the accident had not caused any long-term health damage.[108]

The biggest accident ever involving flammable gas took place in San Juanico outside Mexico City in 1984, in which several LPG[109] tanks exploded, resulting in almost 600 fatalities and around 7,000 people injured. The biggest accident ever involving toxic gas took place in Bhopal in India that same year. An uncontrolled reaction at a chemical factory led to emissions of a large cloud of toxic gas. According to the Indian authorities, the emissions resulted in 15,000–20,000 fatalities and several hundred thousand injured.[110]

In 1976, an industrial accident with a major emission and spread of dioxin, among other chemicals, occurred in Italy in the town of Seveso north of Milan. The event involved evacuation of the population around the site of the accident. The contamination by dioxin and the subsequent cleanup work was very extensive. No one died immediately as a result of the incident, but the delayed injuries in the population have been great. This event brought industrial safety into focus in the EU, and gave rise to the Seveso Directive[111].

[107] *Official Norwegian Report (NOU) 2001:9 The Lillestrøm Accident, 5 April 2000.*
[108] *Tjalvin, G. et al: "Helseundersøkelse etter Sløvåg-ulykken". University of Bergen 2013.*
[109] *Liquefied Petroleum Gas.*
[110] *Encyclopædia Britannica.*
[111] *Seveso-III (Directive 2012/18/EU).*

Dangerous substances,[112] in volumes that may represent a risk to life and health for their surroundings, are handled by more than 10,000 enterprises in Norway. Approximately 340 enterprises are covered by the Major Accident Regulation[113], which implements the Seveso Directive in Norwegian law. The enterprises that handle dangerous substances are scattered throughout the country with concentrations in Eastern Norway (particularly in the counties of Akershus, Østfold and Buskerud) and Western Norway (particularly in the counties of Rogaland and Hordaland). Approximately 80 per cent of the sites are located in these two regions. The bulk of transport of dangerous goods takes place by road. The transport of dangerous goods by road and rail is internationally regulated via regulations based on UN recommendations. Most of the transport of dangerous goods on Norwegian roads consist of three substance groups: flammable liquids (approximately 80 per cent), gas (compressed, liquid or dissolved under pressure, approximately 8 per cent) and corrosive substances (approximately 6 per cent). In 2013, it was calculated that, on average, around 25,000 tonnes of dangerous goods are transported by road and rail in Norway every day.[114]

Risk

Production, storage, transport and the use of dangerous substances present a latent risk to life, health, the environment and material assets. The Major Accident Regulation specifies that enterprises must systematically ensure that they take all necessary measures to prevent accidents and limit the consequences of any event that do occur. This includes securing facilities and transport against sabotage. The likelihood of accidents involving dangerous substances is therefore, to a large extent, linked to the risk of failures in these procedures.

In general, the likelihood of chemical and explosive incidents is low at an enterprise level, but somewhat higher on a national basis. The DSB has, in cooperation with other agencies with responsibilities in this area, identified 12 scenarios within the transport and handling of dangerous substances, each of which could have enormous consequences for life and health, the environment and material assets. The transport of dangerous goods is extensive, and the geographical area of impact is therefore broad.

Accidents with toxic gases occurring near or within densely populated areas may have a major impact on life and health for the population around the accident site. Ammonia and chlorine are the two gases the represent the greatest hazard in Norway. Explosions during transport or in storage areas containing contaminated ammonium nitrate cannot be ruled out either.

The consequences of an accident involving hazardous substances depends on a number of factors - for example, the type of hazardous substances, quantity, temperature, wind direction, location and date and time of accident. In addition, emergency preparedness expertise and capacity, effective warning of the population, and passing on information both before and during an event will affect the severity of the consequences.

In general, the increased use of flammable gas in Norway increases the likelihood of accidents. There are also examples of large, new facilities containing flammable gases that have been located near existing buildings. Over time, previously unused areas in the immediate vicinity of enterprises that handle dangerous substances have also been redeveloped. This land use increases the public's exposure to the hazard these substances may represent. Ageing refrigeration plants that use ammonia also represent a challenge for safety. Such plants are often located in densely populated areas.

Areas in which multiple enterprises that handle dangerous substances have been established, and where there may be high levels of activity linked to the transport of dangerous goods on land and at sea, represent a particular challenge. An incident at an enterprise can propagate to other enterprises and trigger a major accident with very serious consequences for the population in the area. From this perspective, the area's overall risk will be greater than the sum of the individual enterprises' internal risk.

In recent years, analyses have been conducted of the risk associated with two such areas: Sydhavna (Sjursøya) in Oslo[115] and Risavika in Sola municipality in Rogaland.[116] The reports point out that the overall risk must be taken into account in the enterprises' internal safety plans, in the municipalities' emergency response plans, and in the state authorities' regulations and audits.

---

[112] *Flammable, self-reactive and under pressure substances.*
[113] *Regulations on measures to prevent and limit the consequences of major accidents in enterprises in which hazardous chemicals are present (Major Accident Regulations).*
[114] *Institute of Transport Economics (2013), Survey of the Transport of Dangerous Goods in Norway.*
[115] *Norwegian Directorate for Civil Protection (2014) Sydhavna (Sjursøya) – an area with elevated risk.*
[116] *Risavika – comprehensive risk management in areas with an elevated risk, the DSB, Sola Municipality, Rogaland fire and rescue service IKS (RBR), 2015.*

Prevention and emergency preparedness

Chemicals and explosives should be handled without accidents occurring and avoid that dangerous substances fall astray and may be used for criminal acts. Enterprises and private individuals that handle chemicals and explosives have a duty to act with care in order to ensure safe handling and storage, and to prevent accidents. The authorities contribute to prevention through regulations, information, guidance, audits and research and development measures.

The government has adopted a national strategy for CBRNE preparedness. In addition to the areas of chemicals and explosives, the strategy also covers biological agents, radioactive substances and nuclear materials.[117] The Ministry of Justice and Public Security is responsible for the coordination of the chemical (C) and explosive (E) areas. The national platform for chemical and explosive preparedness was established to facilitate comprehensive and coordinated work in the CE area at a directorate level. The national platform aims to develop technical expertise and an emergency preparedness network that can provide advice to responsible preparedness actors during the management and normalisation phase.

The Norwegian Defence Research Establishment (FFI) analyses and identifies CE samples and provides advice and support in the area of chemicals and explosives, also during incidents. According to the National Strategy for CBRNE Preparedness 2016–2020, the Ministry of Justice and Public Security must assess the need and opportunities to designate a chemical institute to assist at local, regional and central levels and strengthen research and development.

Conducting audits on enterprises that must obtain the DSB's consent for their activities is a priority. In total, the health, environmental and safety authorities conduct around 100 audits a year on such enterprises. Municipalities, normally via the fire and rescue service, inspect other facilities that handle flammable, self-reactive or under pressure substances.[118]

The municipalities and enterprises must base their preventive and consequence mitigation measures on risk and vulnerability analyses. Locally, land use is important for minimising the risk that enterprises that handle dangerous substances can represent. There is ongoing work on clarifying which means local and central authorities can use to ensure coordinated risk management in areas with multiple enterprises that handle dangerous substances.[119]

The fire and rescue service, ambulance service, police, municipalities and local industrial safety at the enterprises that have such a scheme, form the backbone of chemical and explosive preparedness at local level. Fire and rescue services have a particular responsibility. There are currently around 1,100 enterprises that have an industrial safety organisation based on the Regulation.[120] Some of these also have an enhanced industrial safety organisation, which also covers environmental and chemical safety, as well as chemical incident fighting using breathing apparatus.

Resource Companies for Mutual Assistance (RCMA) is an emergency preparedness cooperation scheme between a number of major processing companies that have their own industrial safety organisation. The Norwegian Intervention in Chemical Transport Emergencies (ICE) scheme is the industry's network for assistance in case of transport accidents involving dangerous goods.[121] If ICE does not have the competence or expertise about the chemical involved in a dangerous goods transport accident, the Norwegian Coastal Administration can use the EU-based ICE network.

[117] *National Strategy for CBRNE Preparedness 2016-2020, Ministry of Justice and Public Security, Ministry of Health and Care Services, Ministry of Defence.*
[118] *Report to the Storting (white paper) No. 10 (2016–2017) Risk in a Safe and Secure Society.*
[119] *Report to the Storting (white paper) No. 10 (2016–2017) Risk in a Safe and Secure Society.*
[120] *FOR-2011-12-20-1434 Regulations relating to industrial safety and emergency preparedness.*
[121] *Report to the Storting (white paper) No. 10 (2016–2017) Risk in a Safe and Secure Society.*

SCENARIO

10.1 Fire at an Oil Terminal in a City

Fuel is a flammable and explosive liquid and requires a high level of safety and security during transport, storage and distribution. In 2011, a risk analysis was conducted for a fire at the oil terminal in Sjursøya in Oslo. Sjursøya is the largest main tank facility in Norway, located in the capital's port area, and is very important for the supply of fuel in Eastern Norway.

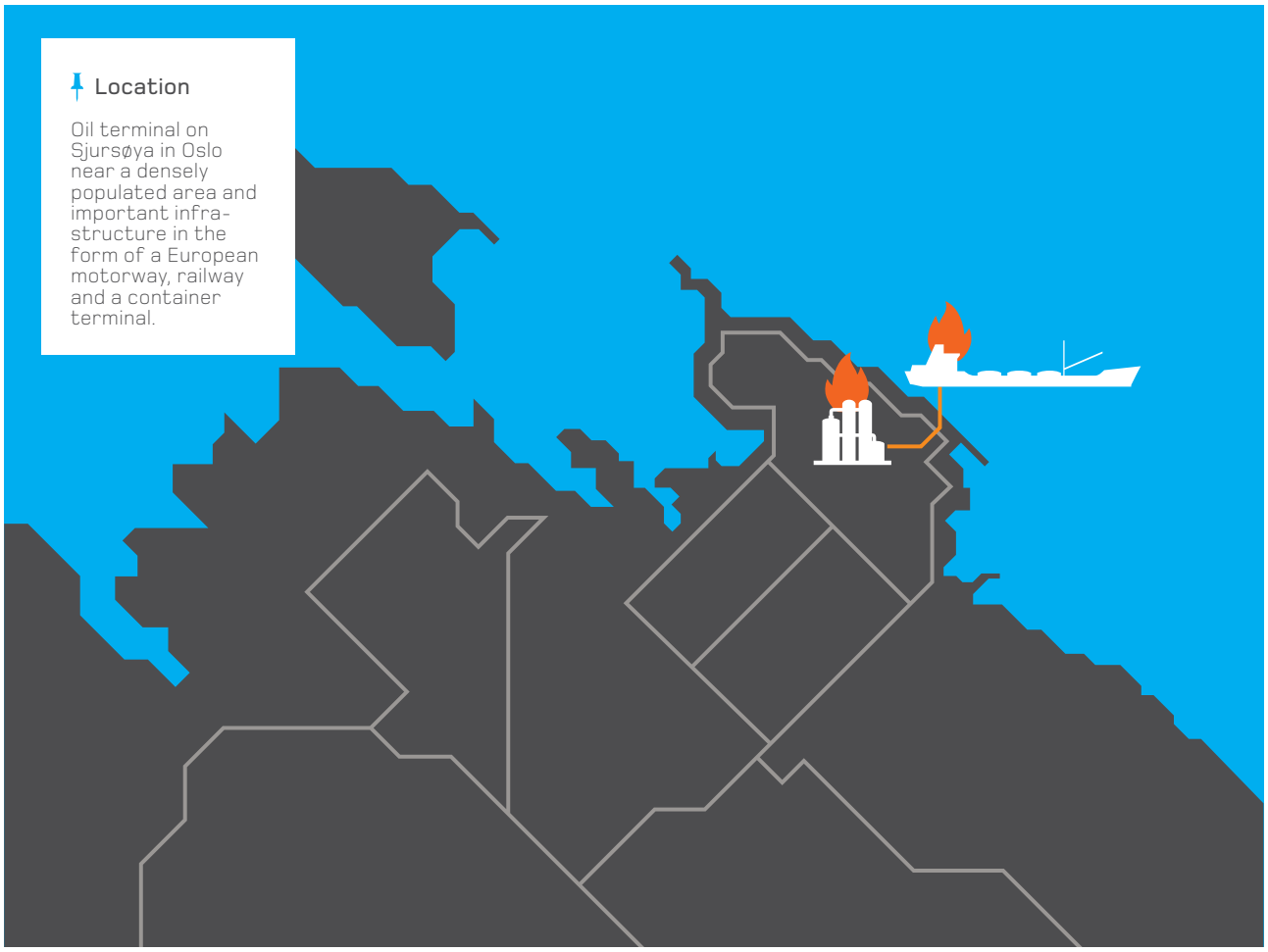
The analysis was reviewed and updated in 2018.

Course of events

An explosive fire occurs while petrol is being unloaded from a tanker to onshore tanks. The fire on the pier where the tanker is moored spreads quickly. The whole tanker is engulfed by flames. After 15 minutes, two onshore tanks catch fire and an explosive, uncontrolled fire develops. The weather is clear, there is a gentle breeze and the temperature is a few degrees above zero. The terminal is located in a densely populated area, and several hundred thousand people can see the fire or smoke from where they are located. Important infrastructure in the form of roads, railways and a container port are located near the oil terminal. It is rush hour and there are slow moving queues in the area.

The dock facility is a total loss and put out of function for several weeks. The onshore tanks and filling stations for tanker lorries are totally destroyed, while the storage tanks that are located inside the mountain at Ekebergåsen and the filling stations for trains are not destroyed. Given total loss of the port facility, petroleum products can no longer be shipped to Sjursøya.

Time	Scope	Similar events
In the afternoon on a weekday in December. The fire lasts for several days. Fuels supplies are disrupted for several weeks.	The onshore tanks hold 16,000 tonnes of petroleum products. The ship has 11,000 m^3 of petrol and 7,000 m^3 diesel on board.	• Lac-Mégantic, Canada, train derailment, 2013. • Buncefield, UK, fire at oil terminal, 2005. • Texas City, USA, refinery explosion, 2005.



Assessment of vulnerability

The enterprise's risk management shall prevent an accident, like the one described here, from occurring. Comprehensive preventive work in the form of barriers, procedures and inspections contributes to a high level of safety and security at such facilities. System failures should not occur, but can never be completely excluded.

The facility on Sjursøya supplies the counties of Eastern Norway with fuel, with the exception of Telemark and Vestfold. Approximately 40 per cent of Norway's fuel consumption is covered by this facility. Sjursøya also handles the aircraft fuel used at Oslo Airport Gardermoen. Fuel can also be accepted at, and distributed from, other facilities in the Eastern Norway region. However, it is uncertain to what extent the existing infrastructure and the capacity of these facilities can compensate for disruptions to deliveries from Sjursøya. Thus, one of the consequences of the incident would be disruption to fuel supplies in Eastern Norway for a period of time. This would especially create problems for road traffic.

Assessment of likelihood

The likelihood of the incident occurring is 0.1 per cent per year, which results in a 10 per cent likelihood of it occurring in a 100-year period. In Analyses of Crisis Scenarios (ACS), this assessment is defined as *low* likelihood. The estimate is based on existing information and knowledge obtained from audits of enterprises vulnerable to major accidents, reports from the enterprises, accident statistics, etc. There are also examples of similar incidents from abroad.

There are 16 main tank facilities in Norway in addition to the facility on Sjursøya. However, given that the other facilities are far smaller and have less activity, the likelihood of incidents is lower here. Other tank facilities could also be struck, e.g. nearby airports, and a similar scenario could also occur in one of the country's two refineries. The likelihood of a large fire occurring in a tank facility on a national basis is, based on discretion, deemed to be ten times the likelihood of it occurring on Sjursøya, i.e. an annual likelihood of 1 per cent. This means that there is approximately 60 per cent likelihood of a major fire occurring in a tank facility in Norway in a 100-year period. This corresponds to *moderate* likelihood in ACS.

Assessment of consequences

The societal consequences of the scenario have been assessed as *medium*. The consequence of this incident that weighs most heavily in the context of ACS, is that of direct and indirect economic losses. However, the scenario also results in the loss of human lives and causes some stress on the daily lives of the population of Oslo and eastern Norway.

Life and health

The incident causes between five and 20 fatalities, primarily due to burn and smoke inhalation injuries. 20–100 people become seriously injured or fall ill as a direct or indirect consequence of the fire. Some of these are people with chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD) and asthma, whose condition would worsen.

The consequences would be small with respect to serious injured and ill people.

Nature and culture

The emission of oil into the sea will leave its mark on nature, but it is assumed that the scope of the damage will be limited both with respect to the area affected and to long-term effects. Air pollution as a consequence of smoke and soot could be significant to the local environment, but the effect will be short-term.

The consequences for the natural environment have been assessed as very small.

Economy

The overall economic losses will be substantial. The direct costs are linked, for example, to the loss of a large volume of petrol and diesel, destruction of the tanker, tank facility and dock facility buildings, vehicles and machinery. There are also other enterprises in the immediate vicinity of the oil terminal that would sustain damage. The decontamination and cleanup would also entail substantial costs.

The indirect losses would be linked to, among other things, the loss of earnings for the facility itself and for the oil companies and petrol stations it is meant to serve, and the losses sustained by neighbouring enterprises. In addition to this come losses due to a lack of fuel for aircraft and road traffic for a period of time.

Based on an overall assessment, it is estimated that both the direct and indirect losses would be in the range of NOK 2–10 billion.

The consequences with respect to both direct and indirect economic losses are considered as large.

Societal stability

The fire would be a dramatic incident that would affect many people. Smoke and flames would be visible from most of the Oslo area. Fire is a familiar phenomenon and the public would, to some extent, understand that proximity to a large oil terminal entails a risk. Even though the smoke would cause discomfort and be hazardous in high concentrations, especially for vulnerable groups, it would be easy to avoid the danger by removing oneself from the most exposed areas. The event results in the hoarding of fuel across Eastern Norway, partly by people making sure they fill up often (topping up) and partly by people hoarding fuel on cans.

The consequences with respect to social and psychological responses have been assessed as small.

The fire would cause major disruptions to the daily lives of a large number of people. It would take a few days to get the fire under control. People in areas close by would be asked to stay indoors, and large amounts of smoke could result in schools and kindergartens being closed for a short period of time. Some nearby residents would be evacuated. The roads and railways that pass Sjursøya would be closed while the fire is burning, and this would result in major traffic delays. This would affect more than 100,000 people. Maritime traffic to and from this part of the Port of Oslo would be heavily affected.

In addition to the immediate consequences, there would be disruptions to fuel supplies for Oslo Airport, petrol stations and other users for a period of time.

Given this, the stress on daily life has been assessed as medium.

Assessment of uncertainty

A lot of knowledge is available about industrial accidents, nationally and internationally. Accident statistics, data from audits of enterprises vulnerable to major accidents and the lessons learned from explosive industrial fires abroad provide a good basis for assessing the risk associated with an incident such as the one analysed here. No major disagreements about the assessments were noted among the experts in 2011.

The likelihood of the incident occurring is not very sensitive to changes in the preconditions. The assessments of the consequences are somewhat sensitive to changes in wind speed and direction. The uncertainty of the likelihood and consequence estimate has been assessed as *small*.

Possible measures

Oil companies have intensified their focus on safety since the Sydhavna report was produced. Procedures and routines to prevent incidents, and emergency preparedness for handling incidents, have been improved. The technical standard of the facility has also been upgraded. It is important that this work continues.

For their part, the authorities have strengthened the inspections at the facilities.

The oil companies and authorities have together worked on improving the safety associated with delivery and supply of petroleum products from Sydhavna. ◎

TABLE 17. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario			◎				10% likelihood of the event occurring in a 100-year period.
Similar events on a national basis				◎			16 comparable, but smaller, facilities in Norway. Two refineries. 60% likelihood in a 100-year period.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities		◎				From 5 to 20 fatalities.
	People affected by serious injuries and illness		◎				20–100 injured or ill people.
Nature and culture	Long-term damage to the natural environment	◎					Insignificant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses				◎		NOK 2–10 billion.
	Indirect economic losses				◎		NOK 2–10 billion.
Societal stability	Social and psycho-logical response		◎				Known type of incident. Scope confined to dock area.
	Stress on daily life			◎			More than 100,000 people affected by traffic problems. Disruptions in fuel supplies in Eastern Norway.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES				◎			Overall moderate consequences.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY			◎				Overall, the uncertainty has been assessed as *small*.

SCENARIO

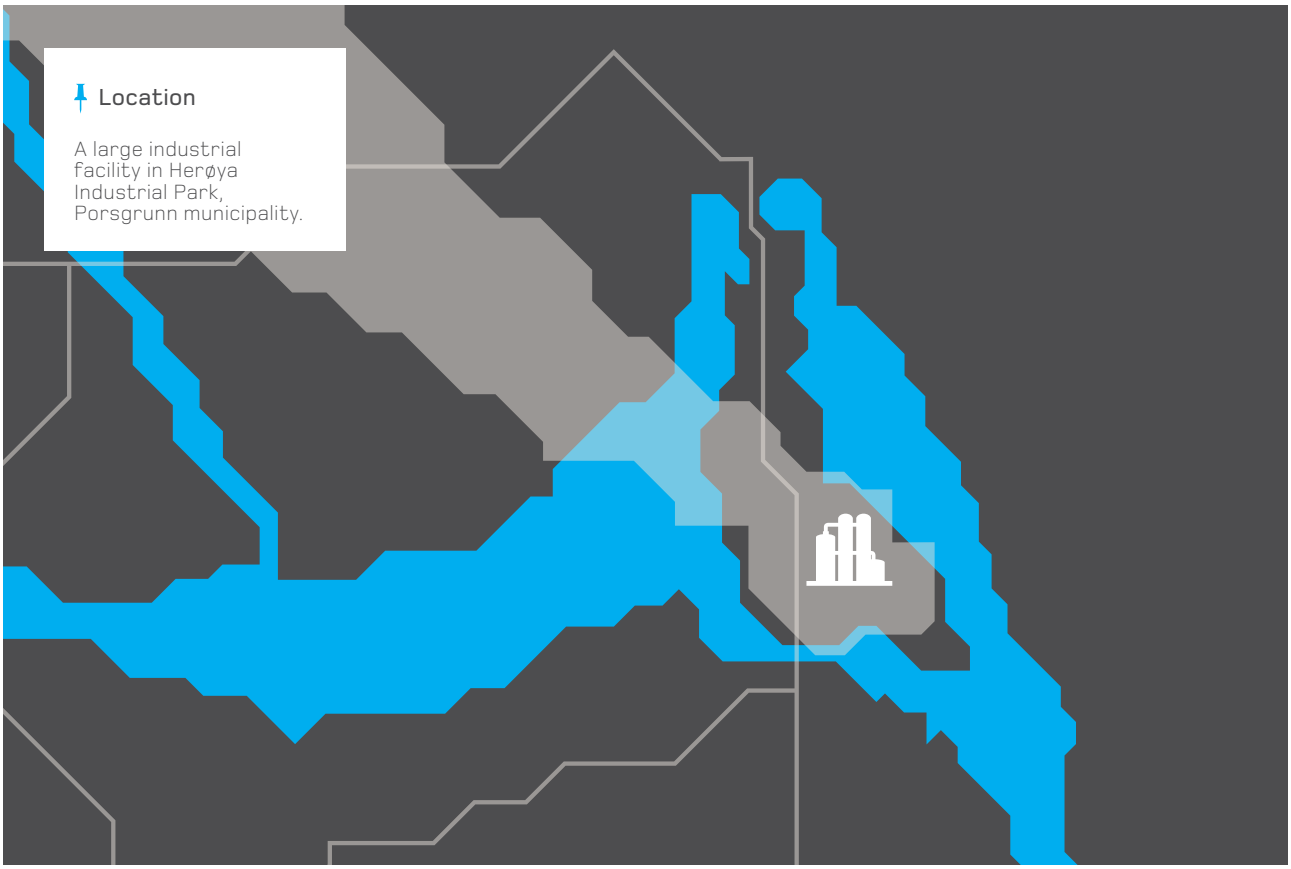
10.2 Gas Emission from an Industrial Plant

Accidents at industrial facilities that handle dangerous chemicals and explosive substances can have significant consequences for the enterprise and the community. Yara is one of the world's largest producers of ammonia. In 2010, a risk analysis was conducted of a gas leak from the company's facility in Herøya Industrial Park in Porsgrunn municipality. The analysis was reviewed and updated in 2018 based on, among other things, information from the risk and vulnerability analyses for Porsgrunn municipality and Telemark county.[122]

Course of events

Yara's ammonia tank in Herøya Industrial Park ruptures. The rupture affects both the inner tank and the outer tank. This results in ammonia streaming out into the catch pond, which fills up. When it comes into contact with the air, the ammonia evaporates and forms a gas cloud. A great deal of gas is produced during the first hour, but this decreases afterwards due to cooling in the surrounding area. The weather is clear and the wind speed is 3 m/s from the northwest to the southeast. The gas reaches residential areas southwest of the facility, in concentrations that are fatal or very dangerous. Residents are asked to remain indoors and close doors and windows.

Time	Scope	Similar events
The incident occurs in the afternoon on a weekday in the autumn. During the first two hours, large volumes of gas disperse, until the leak and dispersal decrease.	34,000 tonnes of ammonia leaks out. Approximately 1,200 people are in the area exposed to the gas.	• Several examples of smaller discharges of ammonia from refrigeration plants in Norway, e.g. at Sunnmøre Dairy in Ålesund 2014 (eight hospitalised). • Major gas leaks internationally: – Bhopal 1984 (methyl isocyanate) – Seveso 1976 (dioxin)



[122] *"Helhetlig risiko- og sårbarhetsanalyse 2015", Porsgrunn municipality 2015 and " Risiko- og sårbarhetsanalyse Telemark 2016", County Governor of Telemark 2016.*

Assessment of vulnerability

The enterprise's risk management shall prevent an accident like the one described here, occurring. Comprehensive preventive work in the form of barriers, procedures and audits contributes to a high level of safety and security at such facilities. System failures should not occur, but can never be completely excluded.

The consequences of leaks of toxic gas from the chemical industry will largely depend on how many people who are near the facility. In many places, such as Porsgrunn, there is a relatively large number of buildings in the zones that might be affected by such an accident.

Assessment of likelihood

The likelihood of a system failure resulting in a major discharge as outlined in the scenario, is very low. It is estimated that the scenario has an annual likelihood of 1: 10,000, i.e. a 1 per cent likelihood of the incident occurring in a 100-year period. In Analyses of Crisis Scenarios (ACS), this assessment is defined as *very low* likelihood. The estimated likelihood is based on an assessment of the expected accident frequency as a consequence of system failure at the facility, and it is based primarily on the existing risk analyses for this type of industrial facility.

The possibility of sabotage, natural events of a hitherto unknown force in the relevant area, or major accidents (such as a plane crash) near the facility, may mean that the likelihood may be somewhat higher than stated here, although still in the category very low.

The facility in Herøya Industrial Park is unique in Norway, and the likelihood of a gas leak occurring of the magnitude described here will not be higher than that for the analysed scenario. The scenario is a worst case scenario. The risk and vulnerability analysis for Porsgrunn municipality is based on a ruptured pipeline, which is a less serious, but more likely scenario.

Assessment of consequences

One general feature of a major emission of toxic gas as described in the scenario is that the immediate consequences are relatively large, but the long-term consequences are limited. An incident such as this will primarily threaten the societal assets Life and health, and Economy.

Life and health

Less than 100 people die as a consequence of the gas leak. The number of injured or ill people is almost 500. High concentrations of ammonia gas can result in serious eye damage, swollen respiratory passages and breathing difficulties. Severe and prolonged exposure can result in loss of consciousness, convulsions and serious lung injuries.[123]

The consequences with respect to fatalities have been assessed as medium, while they have been assessed as large with respect to serious injured and ill people.

Nature and culture

The toxic gas will have some immediate environmental effects, but will not entail long-term or permanent damage to nature.

Economy

The direct economic losses associated with the incident would be linked to the physical damage to the ammonia tank and the loss of 34,000 tonnes of ammonia. The area would have to be decontaminated and the tank rebuilt.

A large number of hospitalisations would entail substantial costs. In addition, there would be losses for the enterprise due to a prolonged production stoppage and possible compensation payouts to those who have suffered losses due to the incident. The incident would also harm Yara's reputation and lead to a fall in the value of its shares. The value of real estate in the area around Herøya would fall, and the reputational harm would also, to some extent, affect the municipality and other enterprises in Porsgrunn and Grenland.

It is estimated that the direct economic losses would amount to NOK 2–10 billion, and the indirect economic losses would amount to more than NOK 10 billion.

The direct economic losses have been assessed as large, and the indirect economic losses as very large.

[123] *Helsenorge.no*

Societal stability

Residents of the area around Herøya Industrial Park are aware that a certain level of risk is associated with being neighbours of the industrial park, not least due to the warning drills involving the Norwegian Civil Defence's sirens. Nonetheless, several characteristics of the incident indicate that it would cause major psychological reactions.

The ammonia gas would spread into densely populated areas so quickly, that those who live and stay in the area in reality have no means of escape, which would cause fear and uncertainty. Panic cannot be excluded. The public expect the industry and the authorities to ensure that such incidents do not occur and the incident would therefore trigger strong reactions.[124]

The social and psychological response of the public has been assessed as medium.

The transport of people and goods by road, rail and sea would stop or be strictly regulated as long as there was a risk of gas pockets remaining in the area. Restrictions on movement could be kept in place for a few days after the incident.

Overall, the consequences in terms of stress on daily lives of the public have nonetheless been assessed as very small.

Assessment of uncertainty

Gas leaks are a relatively known phenomenon and researched risk. A lot of empirical data from incidents, national and international, and audits based on the Major Accident Regulation is available. No major disagreements were noted between the experts who took part in the analysis.

The assessment of likelihood is based on the incident occurring due to the failure of the safety systems. A lot of empirical data is available about the likelihood of accidents at industrial facilities. Therefore, the uncertainty primarily relates to other possible causes such as terrorism and sabotage.

The consequences for the societal asset Life and health are highly sensitive to changes in wind direction and speed, as well as temperature. The weather model used to determine the dispersal of the gas was based on weather observations in the relevant area over time, and the most unfavourable wind direction was assumed. However, slightly weaker wind could result in even more serious consequences for Life and health. A different wind direction or stronger wind would have reduced the consequences.

Overall, the uncertainty (knowledge base and sensitivity) has been assessed as *medium*.

Possible measures

The enterprises' safety and security management systems should prevent the occurrance of incidents involving dangerous substances. The primarily role of the authorities is to regulate and audit enterprises' systems and ensure that they comply with regulations.

The DSB intends to enhance inspections of enterprises in the area of chemicals and ensure that enterprises that do not comply with the regulations are heavily penalised. Audits will pay more attention to security and safety work aimed at countering sabotage. The DSB will explore whether changes to the threat picture indicate a need for round the clock staffing or monitoring at some of these facilities.[125]

Should an incident occur, the consequences for Life and health will largely depend on how many people who are in the vicinity of the leak. Municipalities' land-use policies are therefore important. The DSB has drawn up proposed acceptance criteria for risk, which specify different provisions for the different consideration zones. It is important that these are followed up by the concerned municipalities.

It is important that good warning routines are in place and that the public knows what to do in the event of a leak. Warning routines must be kept up-to-date and practised.

[124] *The assessment was largely taken from "Risiko og sårbarhetsanalyse for Telemark", County Governor of Telemark.*
[125] *Report to the Storting (white paper) No. 10 (2016–2017) Risk in a Safe and Secure Society.*

TABLE 18. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario		◎					1% likelihood of the event occurring in a 100-year period due to the failure of the safety systems. Slightly higher likelihood, although still very low, if one takes into account external factors (sabotage, plane crash, etc.).
Similar events on a national basis		◎					No directly comparable facilities in Norway.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities			◎			Just under 100 fatalities.
	People affected by serious injuries and illness				◎		Close to 500 injured or ill people.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses				◎		NOK 2–10 billion.
	Indirect economic losses					◎	More than NOK 10 billion.
Societal stability	Social and psycho-logical response			◎			Locally, great anxiety, uncertainty, sense of impotence and a risk of panic. More limited response among the rest of the public.
	Stress on daily life	◎					Movement restrictions in the area for a few days. Evacuation of a smaller number of people for a short period of time.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎		Overall large consequences.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed as *medium*.

PHOTO KIMIMASA MAYAMA / EPA

FUKUSHIMA:
Reactor 3 at the stricken Fukushima Daiichi Nuclear Power Plant in Japan in 2011. In the foreground are storage tanks containing radioactive contaminated water.

11

NUCLEAR ACCIDENTS

Background

Some crucial events influence our perception and understanding of risk linked to nuclear accidents. The Three Mile Island accident in the USA in 1979 showed that fairly improbable nuclear accidents can occur. The Chernobyl accident in the former Soviet Union in 1986 showed that the consequences can become very extensive, and that large areas can be affected. The Fukushima accident in 2011 showed that serious accidents can occur in technologically advanced countries, and that they can be triggered by natural disasters.

Although serious accidents occur far away and have no direct impact on Norwegian territory, they create uncertainty and a need for information and management from the Norwegian public authorities. Like the Chernobyl accident the nuclear power accident at Fukushima was classified at the highest degree of severity by the International Atomic Energy Agency's (IAEA's) International Nuclear Event Scale (INES-7). However, the consequences of Fukushima were less serious for Norway than from Chernobyl, and the accident required a totally different type of handling by the Norwegian authorities.[126]

Nuclear accidents can occur in various types of nuclear plants, i.e. in nuclear power plants, facilities for the production and processing of reactor fuel (reprocessing plants) or other fissionable material, and plants for storing used fuel and other radioactive waste. In addition, serious accidents can occur during the transport of reactor fuel. Vessels with nuclear reactors onboard, primarily nuclear submarines and nuclear icebreakers, travel along the Norwegian coast and can release radioactive emissions to the air and sea.

Norway is surrounded by countries in which various forms of nuclear activity take place. Nuclear power stations can be found in Sweden, Finland, Ukraine, UK, Belgium, Germany, France and Russia, among other places. New nuclear power plants are being built in a number of countries, including Finland and Belarus. There are reprocessing plants for used reactor fuel in the UK, France and Russia. Facilities for storing used fuel that could constitute a risk to Norway are primarily located on the Kola Peninsula in Russia.

[126] *StrålevernInfo 8-12 [Radiation Protection Info 8-12]. The Fukushima Accident. www.stralevernet.no ISSN 1891-51-91 (online), 9 March 2012.*

Risk

If a nuclear accident occurs, the consequences could be very serious, depending on where the accident occurs, the type and quantity of radioactive materials involved, how the emissions are transported, and organisations' and authorities' capacity to manage and implement measures. Radioactive contamination causes exposure to ionising radiation, either directly or through ingesting contaminated foods or breathing in contaminated air. This may have an impact on the health of the population in the form of acute radiation sickness, late radiation tissue injuries (principally an increased risk of cancer) and psychological effects. Emissions and the spread of radioactive matter can also have a negative impact on the environment. In addition, radioactive contamination may have consequences such as the contamination of foodstuffs, economic losses as a consequence of reduced market reputation, contamination of property and areas of land, loss of infrastructure, a need for the local community to evacuate immediately or move permanently and social unrest and uncertainty.[127]

Western European nuclear power plants generally have good, redundant safety systems, and measures to reduce both the likelihood and impact are emphasised. Nuclear power plants in the former Eastern Bloc countries, on the other hand, are not regarded as being equally safe, and weaknesses in these nuclear power stations were thoroughly documented by the IAEA in the 1990s.[128] It has been estimated that the likelihood of serious accidents at nuclear power plants in this region is 10 to 100 times greater than would be the case for nuclear power plants in Western countries, with the exceptions of certain older British nuclear power plants. At the same time, we know that Europe's nuclear power plants are ageing, and this increases the chances of accidents.

On the Kola Peninsula, there are numerous plants in which used reactor fuel is being stored under conditions that are fairly unsatisfactory. Some of these plants are located close to Norway, and an accident at one of these could have a significant impact on the environment of the Barents Sea and on Norwegian economic interests. In 2017, with the aid of Norwegian funds, Russia started to transport used reactor fuel out of Andreyev Bay for safe processing and storage in Majak in the Ural Mountains. This will in the long-term significantly reduce the risk of accidents that would have consequences for Norway, although there will be a somewhat heightened risk of an accident until the transport has been completed in 2022-2023.[129]

Investigations into the safety at reprocessing plants in the UK and France show that the greatest risk is linked to storage tanks for liquid waste that contains large amounts of radioactivity. Any loss of cooling at these plants could lead to emissions that would be far greater than those during the Chernobyl accident. Such emissions could affect Norway, depending on the wind and weather conditions.

The Fukushima accident occurred as a result of a powerful earthquake followed by a deadly tsunami, and it demonstrated the way in which natural events can cause nuclear accidents. The emissions from the nuclear power plant of Fukushima Dai-ichi could be measured in Norway, but the values were so low that it did not imply any consequences for health or the environment.[130]

Nuclear activity in Norway is limited to one research reactor at Kjeller. Until March 2018, there was a second nuclear reactor in Halden. Analyses of serious accident scenarios for these plants, in the form of a partial meltdown of the reactor core, have demonstrated that the consequences would be relatively modest.[131] In addition to the rectors named, there are two depots for radioactive waste, one in Himdalen in Akershus county and one in Gulen in Sogn and Fjordane county. Emissions from these would not be expected to have any serious consequences either.

There are relatively high volumes of traffic of reactor-powered vessels along the coast of Norway, and Norway regularly receives visits from such vessels. An accident involving these vessels off the coast of Norway in or just outside Norwegian ports, would have a serious impact on people and the environment in the close vicinity, under certain given conditions.[132] Transport of radioactive waste along the Norwegian coast also constitutes a potential danger.

In addition to accidents at nuclear power plants or other plants that handle radioactive materials, the threat linked to terrorist action against such plants must also be included in the assement of risk. It is also conceivable that terrorist groups could come into possession of nuclear weapons.

---

[127] *Norwegian Radiation Protection Authority (2008): Atomtrusler [Nuclear Threats], Radiation Protection Authority Report 2008:11.*
[128] *Ibid.*
[129] *https://www.nrpa.no/publikasjon/straaleverninfo-07-2017-radioaktivt-avfall-fjernes-fra-andrejevbukta.pdf*
[130] *Vindsand (2011): Befolkningsundersøkelse om informasjon etter kjernekraftulykken i Fukushima [Population study of information after the nuclear power plant accident in Fukushima]. Drawn up on behalf of the Norwegian Radiation Protection Authority, NIVI Report 2011:5.*
[131] *Norwegian Radiation and Nuclear Safety Authority (2008): Atomtrusler, Strålevernrapport 2008:11.*
[132] *Official Norwegian Reports 1992:5 Tiltak mot atomulykker. Anbefalinger om videre styrking av norsk beredskap mot atomulykker.*

The security policy situation is also changing. Norway faces a complex and unpredictable threat picture, with increased military activity in our immediate vicinity as well. Internationally, there are concerns that nuclear and other radioactive materials could go astray and be used for warfare or terrorist purposes.

The relevance of nuclear power plants has increased in recent years, and many people view the construction of nuclear power plants as an opportunity to generate energy with low CO_2 emissions and thus meet the challenges of climate change. In Finland, a new reactor is under construction, and in the UK, Belarus and Russia there are plans to build new nuclear power plants in the years to come. However, there are also countries that are considering discontinuation of their nuclear power plants, such as Germany by 2022.[133]

Prevention and emergency preparedness

The Norwegian Radiation and Nuclear Safety Authority is conducting inspections into safety and emergency preparedness at Norwegian nuclear facilities, including storage of radioactive waste. In addition, there is extensive international cooperation through the IAEA on improving the level of safety at all types of nuclear facilities regarding accidents and deliberate, adverse actions.

Since 1992, a significant portion of the effort has focused on Northwest Russia. Norway has financed measures to strengthen the safety of Russian nuclear power stations, the removal of radioactive strontium batteries from lighthouse beacons, and the scrapping of decommissioned nuclear submarines, as well as protection of the infrastructure in the Andrejev Bay – where used reactor fuel from the Northern Fleet is stored. From the establishment of the nuclear action plan in 1995 until 2017, a total of approximately NOK 2 billion NOK has been appropriated through the national budget for nuclear safety cooperation in Northwest Russia.[134] Future priorities for cooperation will be in facilitating the removal of used reactor fuel from the Andrejev Bay, as well as environmental monitoring and measures related to security and emergency preparedness at the nuclear power stations on the Kola Peninsula and in St. Petersburg.[135]

The Nuclear Action Plan was revised in 2018.[136] In line with the changed international risk picture, there is, in addition to Russia, now a greater focus on nuclear safety in Ukraine. Activities in Belarus and Eurasia are also included in the action plan. Greater weight is being given to reducing the risk of nuclear and other radioactive materials going astray and to preventing acts of terrorism involving the use of such materials. The activities are designed to help protect Norwegian interests.

Norway has permanent emergency preparedness against nuclear events. The objective of the national nuclear emergency preparedness is that it should be possible to manage all potential events, regardless of likelihood. As part of this work, the Norwegian government adopted a set of different scenarios in the spring of 2010 on which the dimensioning of the Norwegian nuclear preparedness is to be based.[137] The six dimensioning scenarios have been categorised based on the challenges they entail with respect to management:[138]

1. Large airborne emissions from plants abroad that can reach Norway.
2. Large airborne emissions from plants or other activities in Norway.
3. Local events in Norway, or in the vicinity of Norway without any local connection.
4. Local events that develop over time.
5. Large emissions to a marine environment in Norway or in the vicinity of Norway, or rumours to this effect.
6. Serious events abroad without any direct impact on Norwegian territory.

A seventh scenario that covers the use of nuclear weapons on or near Norwegian territory is also under development.[139]

---

[133] *https://snl.no/kjernekraft_i_Tyskland*
[134] *https://www.nrpa.no/fakta/90976/om-atomhandlingsplanen*
[135] *Meld. St. 7 (2011 -2012) Nordområdene [Report no. 7 to the Storting (2011 -2012), The Northern Areas].*
[136] *http://www.atomhandlingsplanen.no/*
[137] *Norwegian Radiation Protection Authority (2012): Roller, ansvar, krisehåndtering og utfordringer i norsk atomberedskap [Roles, Responsibility, Crisis Management and Challenges in Norwegian Nuclear Preparedness], Radiation Protection Authority Report 2012:5.*
[138] *Norwegian Radiation Protection Authority, www.stralevernet.no, ISSN 1891-5191 (online), 4 March 2014.*
[139] *The Ministry of Justice and Public Security, the Ministry of Health and Care Services and the Ministry of Defence have, through the National Strategy for CBRNE Preparedness 2016-2020, tasked the Crisis Committee for Nuclear Preparedness with producing a seventh scenario.*

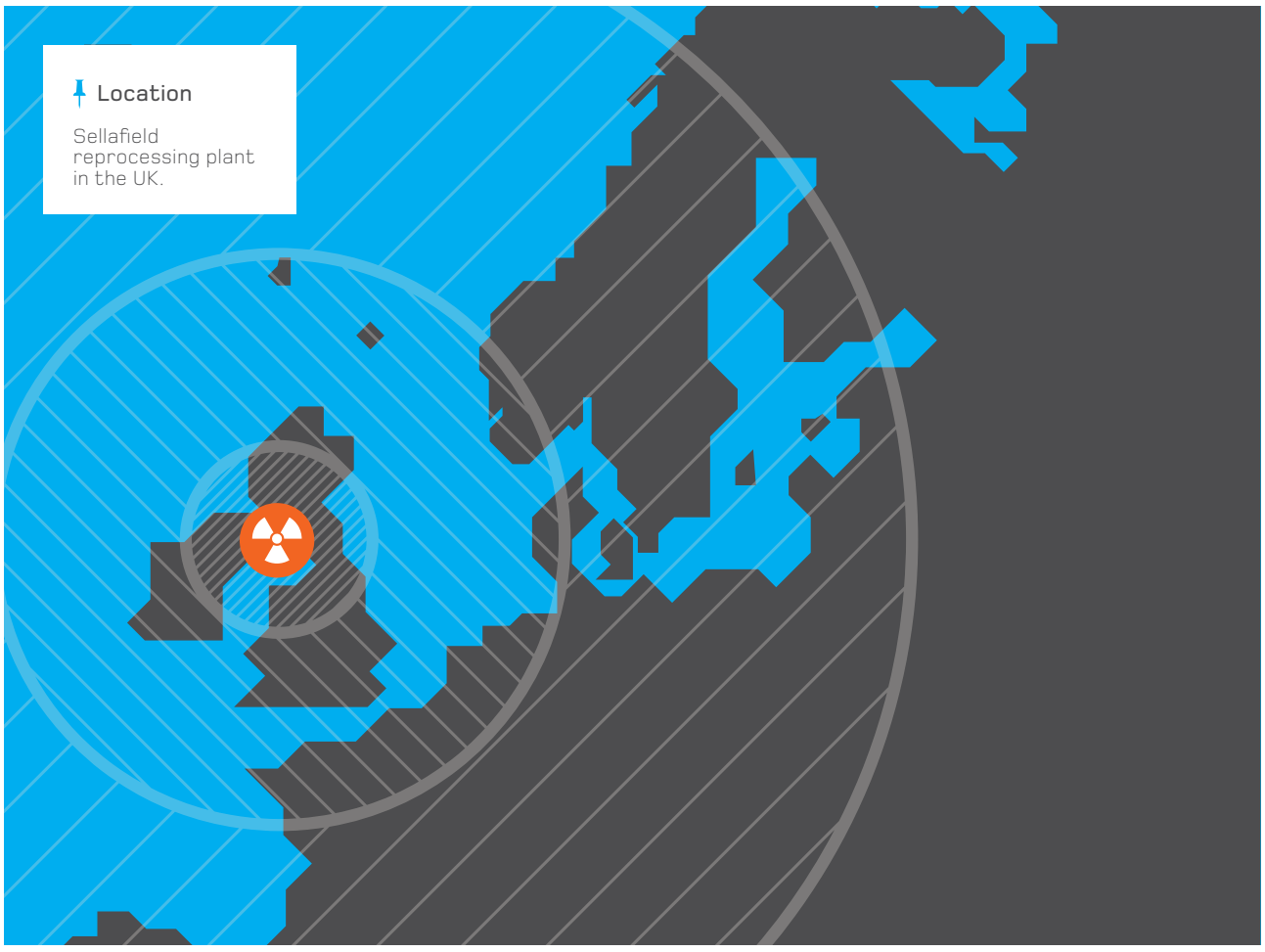
SCENARIO

11.1 Nuclear Accidents

A nuclear accident can occur at different types of nuclear facilities, including facilities for processing reactor fuels and radioactive waste. Following a serious nuclear accident, radioactive emissions could be transported by air currents to Norway and affect public health, nature and the environment.

A risk analysis has been conducted on a specific serious scenario, in which the failure of the reprocessing plant Sellafield in the UK results in an emission of radioactive substances.[140] The risk analysis was conducted in the autumn of 2010, and updated in 2018.

Course of events		
A technical failure at a recovery facility for nuclear fuel at Sellafield in the United Kingdom leads to a shutdown of the cooling system and causes an explosion in one of the waste tanks. The emissions of highly radioactive waste are transported to Norway by air current and the fallout over Norway, especially in Western Norway, is higher than after the Chernobyl accident.		
Time	**Scope**	**Similar events**
The incident occurs in the middle of October, and the emissions reach Norwegian territory after 9 hours. After 48 hours, the emissions can be recorded throughout the country.	100 m^3 of highly radioactive waste is discharged into the atmosphere.	• Three Mile Island accident in the USA in 1979. • The Chernobyl accident in the former Soviet Union in 1986. • Fukushima Dai-ichi in Japan in 2011.



[140] *The analysis is based on the Norwegian Radiation Protection Authority 2009:6. Konsekvenser for Norge ved en tenkt ulykke ved Sellafield-anlegget [Consequences for Norway of a Potential Accident at the Sellafield Plant].*

Assessment of vulnerability

Up until 2018, there were two research reactors in Norway, one in Kjeller and one in Halden. In June 2018, a decision was made to shut down the nuclear reactor in Halden. Highly radioactive waste from the two research reactors is stored at the facilities. Accident and consequence analyses have shown that even very serious accidents at the reactors would not result in radiation injuries to people.[141]

There are several nuclear facilities close to Norway, and an accident at one of these could have serious consequences for Norway as well. The Chernobyl accident in 1986 showed that radioactive emissions can be carried over long distances by air currents. In Norway, Oppland, Hedmark, Trøndelag and Nordland counties saw the most radioactive fallout, which had consequences for South Sámi reindeer husbandry and sheep farmers.

Norway has been an important contributor to the work on securing used uranium fuel from Russian nuclear submarines, which until 2017 was stored in Andreyev Bay on the Kola Peninsula. This nuclear waste is now being moved to the Ural Mountains.[142]

The most important consequence mitigating barrier in the event of a serious nuclear accident is warning and the rapid implementation of protective measures. Nuclear preparedness in Norway is organised through a special Crisis Committee for Nuclear Preparedness, which is under the direction of the Norwegian Radiation and Nuclear Safety Authority (DSA).

A serious nuclear incident would affect the Norwegian society in general. In the longer term, food supplies and national food production would be particularly affected, although the consequences for food production in Norway would depend on a number of factors such as the amount and type of radioactive substances that reach Norwegian territory, which areas are most affected, the crops being grown here and the time of year.

Assessment of likelihood

The annual likelihood of the specific scenario that has been analysed has been assessed as 0.02 per cent, which is equivalent to a 2 per cent likelihood in a 100-year period. This corresponds to *very low* likelihood in ACS.

The scenario has focused on a single nuclear facility in the United Kingdom. There are many nuclear facilities in Europe, both reprocessing plants in France and nuclear power plants in many countries. A serious accident at one of these could have major consequences for Norway if the emissions were large and the wind was blowing towards Norway. The volume of nuclear powered traffic in Norwegian waters and neighbouring areas is clearly increasing. Accidents involving such reactors near the coast could result in large-scale emissions to the air and sea, and have serious consequences for Norway.

The annual likelihood of an accident at a similar facility, with a major leak that affects Norway, has been assessed as 1 per cent, which corresponds to a 65 per cent likelihood in a 100-year period. In Analyses of Crisis Scenarios, this assessment of likelihood is categorised as moderate.

The estimate is based on an assessment of the expected accident frequency at similar facilities, adjusted for characteristics and special conditions at the specific facility. Weather observations are also used as grounds for indicating the frequency and occurrence of air currents that could carry the emissions towards Norway.

Historical data for such events at this particular plant is limited, and the uncertainty associated with the assessment of the likelihood of the adverse event is assessed as *moderate*.

Assessment of consequences

The societal consequences of the given scenario are assessed as *very large*. Estimates of the fallout over Norway are based on existing dispersal models. The consequences have been assessed on the basis of radioactive caesium spreading. The scenario will primarily threaten the societal assets Life and health and Nature and culture.

Life and health

No direct fatalities are expected, but several hundred people could die in the decades after the event, primarily as a result of an increase in the number of cancer cases, if protective measures are not implemented. Several thousand people could develop psychological disorders. The estimates of the consequences for life and health are based on international guidelines.

The consequences for life and health have been assessed as very large.

[141] *https://www.nrpa.no/temaartikler/90276/norske-atomanlegg*
[142] *https://www.nrpa.no/nyheter/93858/radioaktivt-avfall-fjernes-fra-andrejevbukta*

Nature and culture

Nature, the environment and food production will be hit hard, and the slaughter of animals, destruction of milk, etc., could become necessary. The long-term consequences of radioactive fallout would generally be greater for wilderness-based food production (reindeer husbandry, sheep husbandry, mushroom picking, wild game and freshwater fish) than for agricultural production on farmland. The fallout would spread over an area of more than 3,000 km^2 and have a decay rate of many decades.

The consequences for the natural environment have been assessed as very large.

Economy

The economic losses will be particularly large for agriculture and agriculture-based food industries. Costs are associated with both direct costs such as slaughter and clean-up, and indirect costs as a result of lost sales and the loss of reputation. It is assumed in such a scenario that 25 per cent of the meat production and 20 per cent of the milk production are affected. A temporary stoppage of exports of Norwegian seafood can also be expected. It is estimated that the direct and indirect economic losses would each amount to NOK 5 billion.

The consequences of the direct and indirect economic losses have been assessed as large.

Societal stability

Although the event in itself is recognisable, a nuclear accident will create a great deal of social unrest in the population. The consequences will be experienced as life-threatening and as a threat to future generations. Even if the accident takes place beyond Norway's borders, the population knows that the affected areas will be exposed to radioactive contamination that can cause serious illnesses for thousands of people. It is assumed that the scenario will create reactions such as fear and a feeling of powerlessness.

The consequences for social and psychological response among the public have been assessed as large.

Such an event will also have effects on daily life. The fallout would pollute food and drinking water, and measures would be necessary to secure safe food and drinking water for the public. A large number of people would stay at home for a few days instead of going to work, which would lead, for example, to public transport and kindergartens temporarily closing down. It is estimated that 10,000 to 100,000 people would be affected for up to a week.

The stress on daily life has been assessed as small based on the ACS method.

Assessment of uncertainty

Overall, the uncertainty of the assessments of likelihood and consequences has been assessed as *medium*. The historical data for such incidents at this type of facility is limited, while nuclear accidents are a relatively well-known and researched phenomenon compared with other events analysed in ACS.

The likelihood of the emissions affecting Norway is sensitive to changes in the direction of the air currents. The consequences are also sensitive to changes in the wind conditions, as well as the volume of emissions and types of radioactive substances. The uncertainty of the assessments of the different consequence types varies from small to large. The uncertainty of the assessment of the consequences for Life and health is especially high because the emissions would also contain several types of radioactive substances other than what has been used as a basis for this risk analysis.

Possible measures

There are a number of mitigation measures that can be implemented if Norway is affected by radioactive contamination. The Crisis Committee for Nuclear Preparedness has a mandate to implement measures in the emergency phase. These include:

- ordering the securing of areas that are, or might be, heavily contaminated, e.g. in the form of restricting access and traffic, or securing and removing radioactive fragments;
- ordering evacuations of local communities in cases where the source of the leak, e.g. a local reactor, wrecked vessel or satellite fragments, constitute a direct threat to life and health in the local area;
- ordering short-term measures/restrictions in relation to food production, e.g. keeping livestock indoors or postponing harvesting;
- issuing orders/advice in relation to the decontamination of contaminated people:
- issuing advice on whether the public should stay indoors;
- issuing advice on the use of iodine tablets; and
- issuing dietary advice, e.g. advising against consuming certain contaminated foods.

TABLE 19. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario		◎					2% likelihood of the event occurring in a 100-year period.
The likelihood of radioactive fallout in Norway following a nuclear accident at any nuclear plant.				◎			65% likelihood of an incident event occurring in a 100-year period.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities					◎	Several hundred fatalities as a result of a premature death.
	People affected by serious injuries and illness					◎	Several thousand people develop illness.
Nature and culture	Long-term damage to the natural environment					◎	Area of over 3 000 km², duration of several decades.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses				◎		NOK 5 billion from culling livestock and clean-up lasting several decades.
	Indirect economic losses				◎		NOK 5 billion from a drop in sales of meat, fish and dairy products.
Societal stability	Social and psycho-logical response				◎		"Invisible" threat, unclear long-term consequences affecting very many people, reactions such as fear, unrest and a feeling of powerlessness.
	Stress on daily life		◎				Lack of local access to food, drinking water and public transport for up to 100,000 people for three to seven days.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES						◎	The social consequences have been assessed as very large.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed as *medium*.

PHOTO US COAST GUARD / EPA

GULF OF MEXICO, JUNE 2010:
Deepwater Horizon following an explosion on the drilling rig on 20 April 2010.

12

OFFSHORE ACCIDENTS

Background

The petroleum industry is often described as Norway's most important industry. The direct revenues from oil and gas in the National Budget for 2019 amounted to NOK 313 billion, or 22% of the total. The budget also received NOK 232 billion from the Government Pension Fund Global, which has been built up over time using the Government's petroleum revenues.[143] The industry accounted for 14% of gross domestic product (GDP) in 2018.[144]

Oil exploration and extraction at sea is demanding in terms of safety. The potential for major accidents with serious consequences for both people and the environment is significant. The largest oil spill at sea in history occurred as a result of the Deepwater Horizon accident in the Gulf of Mexico in 2010. Gas and oil flowed uncontrollably through the drilling pipe and onto the platform. Shortly after, the gas ignited. The explosive fire took eleven people's lives.[145] The accident also resulted in large quantities of oil leaking into the marine environment. During the 87 days it took to bring the well under control, 350,000-450,000 tonnes of oil leaked out.[146]

The most serious uncontrolled blowout to date on the Norwegian continental shelf is the Bravo blowout in 1977 on the Ekofisk B oil platform in the North Sea The blowout lasted for seven days before it was halted. During this time, 10,500 tonnes of oil had leaked out.[147] With regard to loss of lives, the most serious accident on the Norwegian continental shelf occurred in 1980 when the Alexander Kielland, a semi-submersible rig, capsized in a storm while working in the Ekofisk field. 123 of the 212 people on board perished in the accident. Only the Pipe Alpha accident on the British continental shelf has claimed more lives in the petroleum industry. 167 perished when the platform exploded in 1988.

[143] *Proposition 1 S (2018–2019) National Budget. Yellow Book.*
[144] *https://www.norskpetroleum.no/okonomi/statens-inntekter/*
[145] *Petroleum Safety Authority Norway (2011): Deepwater Horizon-ulykken – vurderinger og anbefalinger for norsk petroleumsvirksomhet. [The Deepwater Horizon accident – assessments and recommendations for the Norwegian petroleum industry]*
[146] *Petroleum Safety Authority Norway (2011): Forslag til scenarioer relatert til akutt utslipp til sjø fra petroleumsvirksomhet i Nordsjøen og Skagerrak i perioden 2010 til 2030 [Proposals for Scenarios related to Acute Spills into the Sea from the Petroleum Industry in the North Sea and Skagerrak during the Period from 2010 to 2030].*
[147] *Ibid.*

Risk

The petroleum industry has to manage a number of different risks: the reservoirs are kept under a pressure that must be controlled during drilling operations and during production. Oil and gas represent a risk of fire and explosion, and there are risks associated with traffic to and around the installations. Major accidents that result in serious injuries or loss of lives, serious damage to the environment or major economic losses, are nevertheless rare. However, less serious incidents occur frequently.

The last major accident on an offshore installation on the Norwegian continental shelf occurred in 1985. One person died when an uncontrolled gas blowout with subsequent explosion and fire occurred on board the West Vanguard, a drilling platform, on the Halten Bank.[148]

The largest acute leak on the Norwegian continental shelf after the Bravo blowout in 1977 (10,500 tonnes of crude oil) involved 3,700 tonnes. The leak occurred in 2007 on Statfjord A in the North Sea. In 1989, 1992 and 2003, leaks occurred involving 1,180, 750 and 630 tonnes of crude oil. However, most of the spills on the Norwegian continental shelf are small. A total of 617 acute crude oil leaks were registered in the period 2001-2016, out of which 59 involved more than one tonne, 18 involved more than ten tonnes, and three more than 100 tonnes. A clear downwards trend can be seen in the total number of leaks of crude oil in the period. However, the decrease is related to the smallest leaks, i.e. those involving under one tonne of crude oil. No corresponding trend can be demonstrated for larger leaks.[149]

Trends in the number and severity of near misses with the potential for the loss of lives or acute pollution may also provide an indication of the development of the risk level in the Norwegian petroleum industry. Of particular interest in this context are trends linked to types of incident with a particular potential for major accidents. One of these is well control incidents. Such incidents can occur if formation fluid[150] flows into the well, and may – if all the technical barriers fail – cause a blowout of oil and gas.

In 2010, a serious situation arose when control was lost of one of the wells being drilled by the Gullfaks C installation in the North Sea. The incident resulted in the long-term loss of a barrier, and only by chance the incident did not develop into a major accident.[151]

Blowouts primarily lead to a risk of acute pollution, but may also develop into accidents where life and health are at risk. The aforementioned Deepwater Horizon accident illustrates this. The number of well control incidents on the Norwegian continental shelf rose in the period 2014-2016, a trend which indicates a higher likelihood of gas and oil blowouts, and therefore also of acute pollution and loss of life and health. 14-15 such incidents, one or two of which were serious, was registered each year during the three year period.[152]

Another relevant type of event is hydrocarbon leaks. These are gas leaks that can cause fires and explosions, and therefore constitute a direct hazard to personnel, along with the possibility of total loss of facilities. If several barriers fail, this type of event can also result in acute pollution. In the period 2001–2016, a total of 87 leaks and damage to risers, pipelines and subsea production installations were recorded. The number of incidents has been declining since 2011. In the period 2014–2016, there was an average of three such incidents per year. In other words, the likelihood of loss of life and acute oil spills due to hydrocarbon leaks decreased during the period.[153]

Structural incidents, including vessels and drifting objects that collide with installations, can also trigger a major accident. The reporting from the last 15 years shows that the number of vessels on collision course has significantly decreased. While in the period 2000–2005, there was an average of 30-35 such incidents per year, this has now been reduced to three.[154]

Overall, there has been a decrease in the number of near misses that could have developed into acute crude oil spills and loss of lives and health during the period 2000–2016. The decrease is primarily due to fewer vessels on collision course with installations. The traffic control centres' control of the relevant marine areas has been an important factor in this development.

The helicopter traffic between the installations and land, accounts for a large proportion of the individual risk for employees on the continental shelf.

---

[148] *The Petroleum Safety Authority Norway (2011): Trends in Risk Level in Norwegian Petroleum Activity (RNNP). Summary Report.*
[149] *The Petroleum Safety Authority Norway (2017): Trends in Risk Level in Norwegian Petroleum Activity (RNNP). Acute Spills. Trends 2016.*
[150] *"Formation Fluid is the naturally-occurring fluids and gases in the pores of a formation rock. The fluid may be oil, gas and/ or water that are contained in geologic formations." (www.petropedia.com).*
[151] *The Petroleum Safety Authority Norway (2011): Trends in Risk Level in Norwegian Petroleum Activity (RNNP). Summary Report.*
[152] *The Petroleum Safety Authority Norway (2017): Trends in Risk Level in Norwegian Petroleum Activity (RNNP). Acute Spills. Trends 2016.*
[153] *Ibid.*
[154] *Ibid.*

The last major accident involving a helicopter in this type of traffic, occurred on 29 April 2016 when a helicopter on its way from Gullfaks B to Bergen Airport Flesland crashed near Turøy. All 13 people on board perished. In Analyses of Crisis Scenarios, aviation incidents are dealt with under the risk area, Transport Accidents.

Prevention and emergency preparedness

The Norwegian Ministry of Petroleum and Energy has overall responsibility for the petroleum industry on the Norwegian continental shelf. The Ministry of Labour and Social Affairs is responsible for safety and the working environment, while the Ministry of Climate and Environment is responsible for the emergency preparedness requirements for private enterprises and municipalities. The Ministry of Transport is responsible for the central emergency preparedness measures to combat acute pollution, including acute oil pollution that is not covered by municipal and private emergency preparedness.

HES requirements for businesses in the Norwegian petroleum industry are strict. The Petroleum Safety Authority Norway is responsible for audits and regulations with regard to work environment and safety in the petroleum business. The Norwegian Environment Agency has corresponding responsibility for the external environment, and stipulates emergency preparedness requirements and performs audits in the petroleum industry. The operators are responsible themselves for taking action to deal with acute spills from petroleum facilities. The operating companies on the Norwegian continental shelf have their own emergency preparedness resources, and they have entered into collaborative agreements through NOFO[155] regarding the establishment, care and further development of emergency preparedness for combating acute pollution. When required, the state can assist with agreed emergency preparedness resources, and the Norwegian Coastal Administration fulfils the duty of the state to carry out audits to ensure that the responsible polluter implements the measures necessary to prevent and limit acute pollution.

PHOTO OLAV HASSELKNIPPE / VG

BLOWOUT ON OIL PLATFORM: The uncontrolled blowout on the Bravo platform in 1977 lasted eight days. The blowout caused the largest oil spill on the Norwegian continental shelf.

[155] *Norwegian Clean Seas Association for Operating Companies.*

SCENARIO

12.1 Oil and Gas Blowout

Petroleum activities on the continental self are technically demanding. Oil and gas represent a risk of fire and explosion, and oil spills can cause immense damage to the marine environment. There is an intense focus on maintaining a high degree of safety. Nonetheless, serious incidents cannot be excluded. In 2011, a risk analysis was conducted of an oil and gas blowout during the drilling of a well in the North Sea. The analysis was updated in 2018.

Course of events

A critical mistake is made during drilling operations on a normal-sized drilling installation in the Troll-Oseberg area off the west coast of Hordaland county. A number of safety barriers fail, including the blowout valve, which leads to gas streaming out through the borehole and up onto the deck. The gas covers large parts of the installation and ignites after a few minutes. A violent explosion occurs with subsequent fire on board the rig on which approximately 100 people are located. Large volumes of oil start to flow out into the sea.

Time	Scope	Similar events
43 days.	*Discharge rate: 7,000 tonnes/day.* *Total discharge volume: approximately 300,000 tonnes of oil.*	• The Deepwater Horizon accident in the Gulf of Mexico in 2010. Blowout and explosion. 350,000–450,000 tonnes of crude oil. Eleven fatalities. • The Piper Alpha accident in the British sector of the North Sea in 1988. Blowout and explosion. 167 fatalities. • Blowout on Ekofisk B in the North Sea in 1977. 10,500 tonnes of crude oil. No fatalities. • There have been several near misses on the Norwegian continental shelf that could have had very serious consequences, e.g. in the Gullfaks field in May and December 2010 and in the Snorre field in 2004.

Assessment of vulnerability

The safety aspect is of central importance in the petroleum industry due to the fire, explosion and pollution risks associated with the exploration and production of oil and gas. The enterprises' risk management is supposed to prevent an accident, such as the one described here, from occurring. Comprehensive preventive work in the form of barriers, procedures and inspections contributes to a high level of safety. System failures should not occur, but can never be completely excluded.

Besides the direct impact of the accident, large oil spills at sea will cause problems for fisheries and aquaculture industries in the polluted area.

Assessment of likelihood

The scenario comprises several relatively rare events: blowout, large gas emissions that ignite and a very long-term discharge. The likelihood of such a large incident will be the product of the likelihood of each of the three elements included in it, and is therefore very low. The annual likelihood of this scenario occurring on the specific drilling installation is estimated to be 1:500,000, or 0.0002 per cent. Therefore, the likelihood of the event occurring on this installation in a 100-year period is 0.02 per cent. In Analyses of Crisis Scenarios, this assessment is defined as *very low* likelihood.

A total of around 200 wells were drilled in the Norwegian continental shelf in the period 2013–2016.[156] If we assume that the activity on the installation in the scenario has an average safety level, there is a 4 per cent likelihood of such an incident occurring on the Norwegian continental shelf in a 100-year period, i.e. the likelihood of the incident occurring is *very low*.

It should be emphasised that the specific scenario consists of a blowout, ignition and a major oil spill. The likelihood of a blowout without ignition is ten times larger than one with ignition.[157] An incident without ignition could also have very serious consequences.

Assessment of consequences

The scenario will primarily threaten the societal assets Nature and culture, and Economy. In addition, the scenario will entail what is defined in Analyses of Crisis Scenarios as social and psychological reactions.

The overall consequences have been assessed as large.

Life and health

The scenario is based on a five minute timeframe passing from when the gas is detected on the deck, until the explosion and fire occur. There is therefore a limited possibility of carrying out an evacuation, and the subsequent fire will make evacuation even more difficult. Compression injuries and burns as a consequence of the explosion and fire will be virtually unavoidable. It is estimated that between 5 and 20 people will be killed as a consequence of the explosive fire.

It is assumed that a large proportion of the remaining people on board the rig will incur serious injuries, either directly from the explosion/fire or during evacuation. In addition, it is assumed that many of the survivors of the event will experience post-traumatic stress. It is estimated that the total number of injured will range from 20 to 100 persons.

The consequences for fatalities and serious injured and ill people have been assessed as small based on the criteria used in Analyses of Crisis Scenarios.

Nature and culture

Even if natural and chemical dispersal (dissolution) and mechanical collection reduce the volume of oil that reaches the shore zone, oil slicks can be expected to affect up to 3,000 km of coastline, especially in Western Norway. With such widespread slicks, it will be unavoidable for environmentally vulnerable areas not to be affected. A very large number of seabirds will be affected. However, there is some uncertainty about how, and to what extent, fish and spawn will be affected by such a spill.

The consequences for the natural environment have been assessed as very large.

[156] *The Petroleum Safety Authority Norway (2016). Trends in Risk Level in Norwegian Petroleum Activity (RNNP) - Acute Spills.*
[157] *According to SINTEF at the analysis seminar in 2011.*

Economy

The direct economic costs of an event like this will be high. The loss of a rig, materials and equipment alone will amount to several billion Norwegian kroner, and the lost oil itself has a value of more than NOK 1 billion (2011). Added to that, major costs will be linked to long-term management and restoration work. Based on the numbers from previous events, it is assumed that the total loss will be up to NOK 10 billion.

The incident could also affect operations on installations near the accident site. In addition, oil slicks along the coast may also affect the aquaculture industry, in the form of the soiling of production facilities and a need to move facilities, as well as possibly culling. The incident could potentially also cause uncertainty in the market with regard to quality and food safety. The reputation of the fisheries industry could also be impacted, as could the tourism industry. The indirect economic losses of the incident are difficult to estimate, but are set here at NOK 2–5 billion.

Both the direct and indirect economic losses would be large.

Societal stability

The loss of human life and extensive damage to nature and the environment will entail strong reactions in the population. The petroleum industry's safety regime is meant to ensure that such incidents do not happen. The public also expects the authorities and industry to be prepared to deal with such an incident, should one occur. Initially, this may lead to questions concerning responsibility and blame, in which questions about inadequate safety, emergency preparedness and management would be important. The incident would result in greater scepticism towards the petroleum industry and the authorities' policies related to oil extraction.

The incident would trigger a large social and psychological response.

Assessment of uncertainty

The knowledge base used for the assessment of likelihood is regarded as very good. There is extensive access to data and experience from similar incidents and near misses on the Norwegian continental shelf and abroad, as well as from risk analyses, statistics and sectoral analyses. Oil and gas blowouts are a known and well-researched phenomenon.

The likelihood estimate is based on this being a concurrence of several rare incidents (blowout, gas leak with ignition and long-term discharge). However, the consequences may be serious even without such simultaneity, depending on the volume discharged, the properties of the oil and the wind and weather conditions. However, minor changes would be of limited significance for the result. The sensitivity of the results of the analysis has, therefore, been assessed as *small* to *medium*.

Overall, the uncertainty associated with the assessments of likelihood and consequences in the Oil and Gas Blowout scenario has been assessed as *medium*.

Possible measures

In Report to the Storting (white paper) No. 12 (2017–2018) Health, Safety and Environment in the Petroleum Industry, the Government describes its ambitions and expectations for the further development of safety work. One central requirement in the petroleum regulations is that stakeholders must continually develop and improve their level of health, safety and the environment (HSE). The Government specifically points to the importance of ensuring that HSE requirements are met, both by the licensee's side in relation to operators and by operators, in relation to suppliers further down the chain.

In 2015, the Norwegian Coastal Administration produced a report based on the scenario presented here and the Collision at Sea scenario, see p. 152.[158] This points out that cooperation with the petroleum industry on plans for the government takeover of oil pollution control missions is an important element of the management of extreme pollution incidents within the petroleum industry.

Following this, a national emergency preparedness plan has been developed as an overarching structure for all participating actors' own plans and a 'bridging document' that facilitates the government takeover of the management of an extreme pollution incident caused by the petroleum industry.

A greater focus on exercises and training is also recommended, especially exercises that challenge all of the elements of the emergency preparedness coordinated by the Norwegian Coastal Administration. This will also include the receipt of international assistance. ◎

[158] *"Beredskapsanalyse. Verstefallshendelser akutt forurensing, vurderinger og anbefalinger", Norwegian Coastal Administration 2015.*

TABLE 20. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario		◎					0.02% likelihood of the incident occurring.
Similar events on a national basis		◎					Approximately 200 wells are drilled every year (2013–2016). 4% likelihood of the incident occurring.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities		◎				5–20 fatalities as a result of an explosive fire.
	People affected by serious injuries and illness		◎				20–100 injured or ill people as a direct or indirect consequence.
Nature and culture	Long-term damage to the natural environment					◎	Oil slicks affecting up to 3,000 km of coastline.
	Irreparable damage to the cultural environment	◎					Insignificant.
Economy	Direct economic losses				◎		Up to NOK 10 billion.
	Indirect economic losses				◎		NOK 2–5 billion.
Societal stability	Social and psycho-logical response				◎		Difficult to avoid, expectations of crisis management, reactions such as anger, mistrust and feeling of powerlessness.
	Stress on daily life						Not relevant.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎		Large consequences overall.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed as *medium*.

PHOTO PER E. KNUDSEN / RØYKEN OG HURUMS AVIS / NTB SCANPIX

OSLOFJORD TUNNEL 5 MAY 2017:
A lorry full of paper caught fire around 2.2 kilometres from the tunnel entrance.

13

TRANSPORT ACCIDENTS

Background

There are various kinds of risk in the transport sector that must be met in different ways. Each of the four means of transport experience a relatively large number of accidents that are generally handled by the sector itself. Road traffic accidents are the biggest challenge. However, the sector faces a complicated and complex risk, threat and vulnerability picture. The safety challenges are increasingly related to climate change, ICT security, major accident hazards and terrorist threats.[159] These are risks that transcend sectors and cannot be handled by the transport sector on its own.

Road traffic accidents are the biggest challenge within transport safety in terms of the number of fatalities and seriously injured. Norway has, for many years, had one of the best traffic safety records in the world with the fewest fatalities per capita. However, the Vision Zero – a vision that envisages zero accidents involving fatalities and seriously injured in the transport sector – entails an even more ambitious goal. Safety levels in railway transport and maritime transport are generally high. The level of aviation safety in Norway ranks among the best in the world and the number of serious incidents is low.

Risk

The accidents related to the various means of transport have separate profiles. Road traffic accounts for around 90 per cent of all fatal accidents. However, in nine out of ten road fatal traffic accidents only one person was killed. The other means of transport experience substantially fewer accidents, but there are far more fatalities per accident.

Major accidents

Major accidents in the transport sector are defined as events with at least five fatalities. During the period from 1985 to 2014, there were 37 major transport accidents in Norway with a total of 659 fatalities. Major transport accidents account for 90 per cent of all the major accidents in Norway during the period. The trend is towards fewer major accidents, but with a few more people killed per accident.

Road traffic accidents

In the ten years from 2007 to 2016, an average of 181 people were killed in road traffic accidents per year. In 2017, the number of fatalities had fallen to 109. That is 26 fewer dead than in 2016, and the lowest figure since 1939. However, the big difference is that in 1939 there were around 100,000 vehicles registered in the country, compared with around 3.3 million in 2017. The number of fatalities has been falling ever since the peak year 1970, when 560 people lost their lives in road traffic accidents.

[159] *Report to the Storting (white paper) No. 33 (2016–2017) National Transport Plan 2018–2029, page 209.*

Accidents in tunnels are rarer, but often have more serious consequences than those that happen outside tunnels. Most accidents in tunnels occur near their openings, while the most serious accidents and fires occur in the middle of the tunnel.

On Thursday, 23 June 2011, a Polish registered lorry caught fire, due to an engine problem, in the approximately 7.3-kilometre long, subsea Oslofjord Tunnel. 25 out of 34 road users got out of the tunnel unassisted. Nine road users were later evacuated from the tunnel by rescue crews. In its investigation report, the Accident Investigation Board Norway concluded that the risk for road users was increased by the tunnel's safety equipment and emergency preparedness solution not being adequately designed for self-rescue, and several road users were thus caught in the smoke.

On 5 May 2017, another foreign registered lorry caught fire in the Oslofjord Tunnel. The incident caused no serious injuries, although two road users had to be evacuated after seeking refuge in one of the tunnel's rescue shelters. The Accident Investigation Board Norway's investigation shows there were a number of similarities between the vehicles that caught fire in the Oslofjord Tunnel in 2017 and 2011. Both fires were due to engine breakdown caused by overloading the engine.

An empty lorry caught fire in the 11.5-kilometre long Gudvanga Tunnel in Sogn og Fjordane on 5 August 2013. The lorry caught fire around 3.5 kilometres into the tunnel from the Flåm side. Many vehicles and a coach full of Japanese tourists were stuck in the smoke inside the tunnel. 67 people evacuated themselves or were evacuated from the tunnel and taken to hospital. 28 people suffered acute smoke inhalation injuries and five were seriously injured.

On 11 August 2015, there was another fire in the Gudvanga Tunnel, this time involving a Swedish tourist coach. The 32 passengers on the coach were evacuated in an empty van that happened to arrive on the scene. Five people in three other vehicles were stuck in the smoke in the tunnel and evacuated by rescue personnel after around 1.5 hours. Four people were treated for smoke inhalation injuries in hospital.

The fire in the Skatestraum Tunnel in Sogn og Fjordane on 15 July 2015 was the most serious tunnel fire in Norwegian history. A tank trailer that had become detached from its tractor unit and hit a tunnel wall sprung a leak. 16,500 litres of petrol leaked into the tunnel. The petrol – and fire – spread almost 500 metres into the tunnel. The fire escalated quickly and there was very little time to evacuate. The tunnel was closed for five months and the repair costs exceeded NOK 60 million.

On 17 April 2017, a road sweeping vehicle carrying several hundred litres of diesel and hydraulic oil caught fire in the 6.3-kilometre long Fjærland Tunnel in Sogn og Fjordane. 13 people were sent to hospital with smoke inhalation injuries. All of the road users had to rescue themselves on foot.

Aviation accidents

In 2017, there were 19 registered accidents involving Norwegian aeroplanes or helicopters, four of which involved fatalities. The average number of accidents per year in Norwegian aviation in the period 2009–2017 was 18, two of which per year have involved fatalities.

There have been three serious helicopter accidents in Norwegian aviation in the last ten years. One helicopter crashed into the sea at Horten on 27 January 2010. The helicopter stopped in mid-air when it encountered a fog bank, lost control and crashed into the sea. All four on board perished. An ambulance helicopter from the Norwegian Air Ambulance Foundation crashed during a rescue mission in Sollihøgda in Buskerud on 14 January 2014. The helicopter hit a high-voltage line 20–30 metres above ground and two people perished in the crash.

On 29 April 2016, an Airbus Super Puma helicopter lost a rotor and crashed at Turøy Island in Hordaland County. 13 people – 11 oil workers and two pilots – perished. The helicopter dropped 640 metres in the last ten seconds before it hit an islet. The Accident Investigation Board Norway believes a fatigue failure in the gearbox was the direct cause of the accident. The helicopter was on its way from the Gullfaks B platform in the North Sea to Bergen. The Turøy accident was the first helicopter accident in the Norwegian oil industry since 1997. 12 people died when a Super Puma helicopter crashed on its way to the production vessel, M/S Norne, in the Norwegian Sea.

The Operafjell accident in 1996 is the most serious aviation accident in Norway to date. 141 people lost their lives when a Russian aeroplane from the company Vnukovo Airlines made a navigation error and crashed into the Operafjell mountain a few kilometres away from Longyearbyen. The aeroplane was carrying miners from Ukraine and Russia. 125 adults and five children, plus the crew of 11, perished.

Railway accidents

Norwegian railway safety is among the best in Europe. The long-term trend shows a continuing low number of incidents. In the last few decades, there have on average been four to five railway accidents a year. Most of the accidents occur in connection with people or vehicles crossing tracks. No rail passengers have died in accidents on Norwegian trains in the last decade[160].

There have been two major railway accidents in Norway in the last 50 years. On 4 January 2000, two trains collided close to Åsta Station on the Røros line. Immediately following the collision, a fire broke out in the trains and 19 people lost their lives. The traffic control centre became aware that the trains were on a collision course around one minute before the collision, but were unable to prevent it. The previous major accident happened on the Dovre line in 1975 when 27 people died in a collision north of Tretten Station.

Three people were killed and four injured on Sjursøya when they were hit by a train set that ran out of control from Alnabru on 24 March 2010. The traffic control centre guided the train set in the direction of Sjursøya, where it derailed and continued through a terminal building. The train set consisting of 16 wagons belonging to Cargo-Net had been parked at Alnabru freight depot in anticipation of use later in the day. The train set reached a maximum speed of more than 100 kmph while rolling downwards towards Sjursøya port terminal. The Accident Investigation Board Norway deemed the main cause of the accident was human error.

Maritime accidents

Statistics from the Norwegian Maritime Authority show that accidents involving serious injuries on vessels have fallen by 56% since 2004. Accidents involving serious injuries on vessels often include injuries to people, loss of human life or acute pollution. The number of groundings has risen by 62% since 2004, the number of contact accidents has more than doubled, while the number of collision accidents has fallen by 43%. The increase in the number of incidents involving less damage may be due to a higher rate of reporting in the last few decades.[161]

The three largest Norwegian maritime accidents in the last 30 years are the Scandinavian Star fire in 1990, the Sleipner capsizing in 1999 and the Rocknes capsizing in 2004.

The most serious ship disaster in modern Norwegian history is the fire on board the car ferry, Scandinavian Star, in Skagerak in 1990 in which 159 people perished. Most of the dead were Norwegians. On the night of the accident the ship was carrying 383 passengers and a crew of 99. On its way to Frederikshavn in Denmark on the night of 7 April, the ferry was hit by several fires that started in different locations. The ship was towed into Lysekil in Sweden, where the fires were extinguished. There is much to indicate that the fires were set deliberately, although the cause of the fire has not been definitively clarified.

16 people died on 26 November 1999 when the high-speed catamaran, M/S Sleipner, crashed into a rock called Store Bloksen while en route from Haugesund to Bergen. A short time after, many vessels converged on the scene of the accident and rescued 69 people from the sea. The Accident Investigation Board Norway concluded that the direct cause of the accident was a navigation mistake.

On 19 January 2004, the bulk carrier, M/S Rocknes, capsized in Vatlestraumen right outside Bergen. The vessel's course strayed too far starboard and it hit one of the shallows just by a lighthouse. The vessel listed and capsized a short time after. 18 of the 30 people on board perished. Three people were brought out alive after sitting for seven hours inside the capsized hull. M/S Rocknes discharged 470 m^3 of heavy oil and 70 m^3 diesel during the capsizing. The poor weather prevented the oil pollution control equipment from working effectively and 45 kilometres of coast sustained heavy pollution. Between 2,000 and 3,000 seabirds were lost as a direct consequence of oil contamination in the Hjelte Fjord.

The Ministry of Transport bears overall responsibility for the transport areas of aviation, maritime traffic, road traffic and railways. The National Transport Plan (NTP) presents the Government's overall transport policy. The plan covers the transport agencies Avinor, the Norwegian Coastal Administration, the Norwegian Public Roads Administration and the national railway infrastructure company. The NTP is published every four years, and the current plan is Report to the Storting (white paper) No. 33 (2016–2017) National Transport Plan 2018–2029.

Prevention and emergency preparedness

The Ministry of Transport bears overall responsibility for the transport areas of aviation, maritime traffic, road traffic and railways. The National Transport Plan (NTP) presents the Government's overall transport policy. The plan covers the transport agencies Avinor, the Norwegian Coastal Administration, the Norwegian Public Roads Administration and the national railway infrastructure company. The NTP is published every four years, and the current plan is Report to the Storting (white paper) No. 33 (2016–2017) National Transport Plan 2018–2029.

[160] *Report to the Storting (white paper) No. 33 (2016–2017) National Transport Plan 2018–2029.*
[161] *Report to the Storting (white paper) No. 35 (2015–2016) On Course – Preventive maritime safety measures and acute pollution preparedness, chapter 3.3.*

Transport safety
The interim traffic safety goal in the previous NTP (2014–2023) was to halve the number killed and seriously injured in road traffic during the period of the plan. This entails a reduction in the number of fatalities and seriously injured from around 1,000 to 500 a year. Halfway through the period, Norway is on track to achieving this target. In 2017, 109 fatalities and 665 seriously injured in road traffic were registered – a total of 774 fatalities and seriously injured.

For the plan period 2018–2029, the Government has set an interim goal of halving the numbers in the next plan period as well: "By 2030, the number killed and seriously injured in road traffic must be reduced to a maximum of 350, while the high level of safety in other means of transport must be maintained and strengthened."

Tunnel safety
In 2007, the Road Tunnel Safety Regulation, which is based on an EU directive, came into effect for tunnels on national roads. 255 tunnels in the national road network are covered by the regulation. Since 2015, the regulation has also applied to county roads (municipal roads in Oslo).[162] The purpose of the regulations is "to ensure the lowest permissible level of safety for road users in tunnels in the case of requirements to prevent critical incidents that may put human life, the environment and tunnel installations at risk and to ensure protection in the case of accidents."

The requirements must be met by all tunnels by the end of 2019. In addition to the regulatory requirements, new ICT solutions, among other things, will help to gradually raise safety levels in Norwegian tunnels.

Civil protection
The consequences of extreme weather and climate change present an increasing challenge for safety and reliability in the transport systems. In particular, the increase in frequency and intensity of short-term precipitation is highly relevant with respect to flooding and landslides. Parts of the road and railway network are currently not robust enough to tackle the challenges associated with large volumes of water. In accordance with the NTP 2018–2029, the transport agencies will continue to work on reducing vulnerability to climate change. Anticipated climate change must be assumed when investing and operating infrastructure.

Changes in the security policy environment have made protection and emergency preparedness against intentional acts an important focus area. Recent events in Europe have shown that the transport sector is a vulnerable target for terrorists. Large parts of the infrastructure is open and easily accessible, and an attack could have serious consequences for life and health and result in the knocking out of societal critical functions

According to the NTP, the prevention, detection and management of adverse ICT events must especially be prioritised. Digitalisation of the transport sector is increasing the dependency on electronic communications. Failures in, or attacks against, critical ICT systems can both cause accidents and put important transport functions out of play. The Government wants to reinforce safety, security and emergency preparedness in important control systems and terminals.

Based on the challenges common to the entire transport sector, the Ministry of Transport has identified three areas that will be especially prioritised in the transport sector:

- Climate adaption
- Information and ICT security
- Protecting critical objects, systems and functions.[163]

[162] *Applies to tunnels longer than 500 metres with certain traffic volumes.*
[163] *The discussion was largely taken from Report to the Storting (white paper) No. 33 (2016–2017) National Transport Plan 2018–2029, chapter 12 Public safety in the transport sector.*

SCENARIO

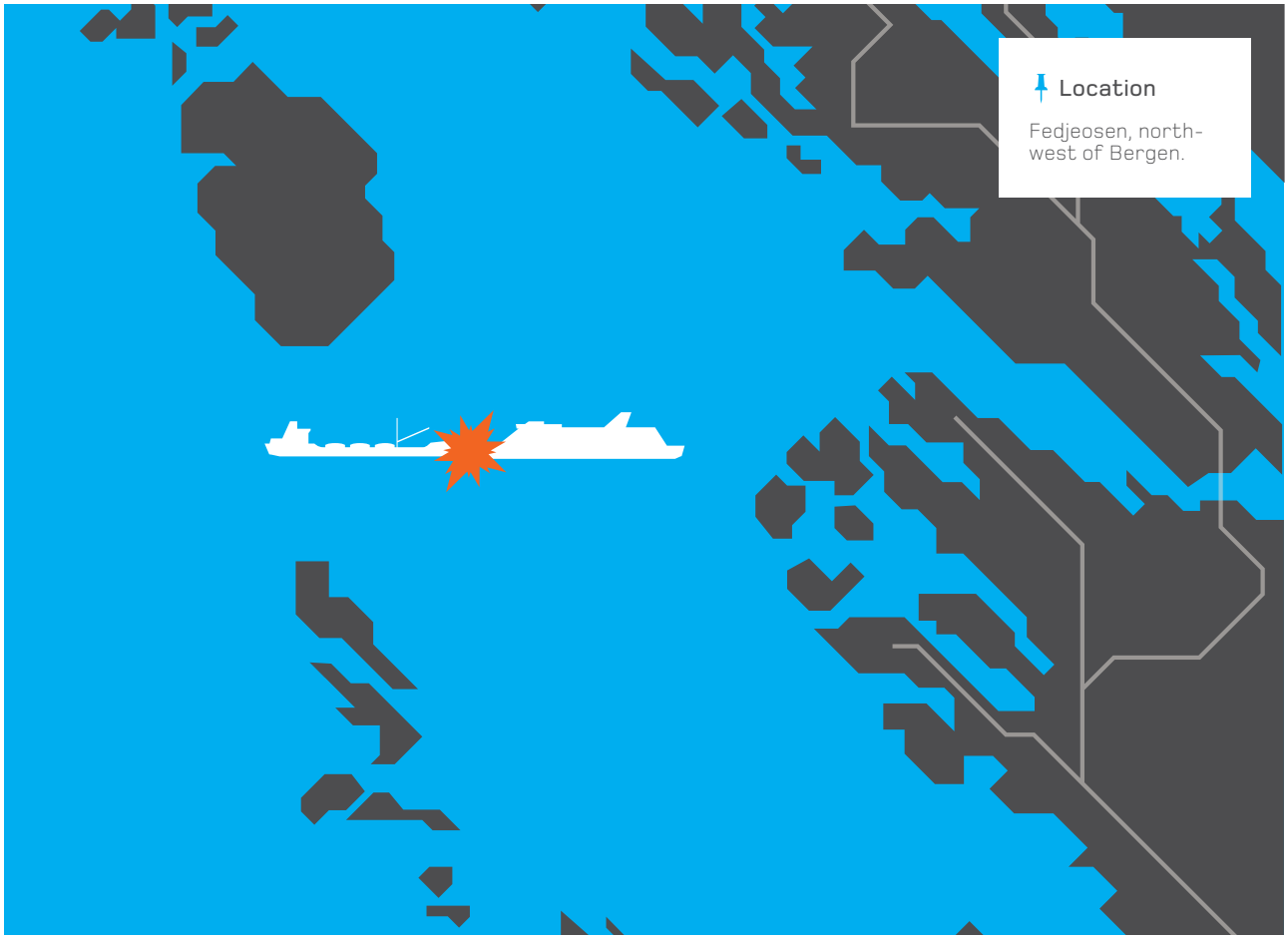
13.1 Collision at Sea off the Coast of Western Norway

Maritime traffic is growing. In Norwegian waters, this is especially true with respect to tankers and large cruise vessels. At the same time as traffic is growing, it has over time become safer, including as a consequence of new navigation tools and enhanced surveillance and traffic control. Despite this, serious maritime accidents remain a possibility. In 2010, an analysis was conducted of a scenario in which a cruise ship collides with a large, fully loaded tanker off the coast of Western Norway. The analysis was reviewed and updated in 2018.

Course of events

A large cruise ship is making its way southwards along the coast of Western Norway from Geiranger to Bergen. Early in the morning, a fault occurs in the electrical system, which causes complete engine failure. Visibility in the area is restricted to sea fog. A tanker is making its way from the Sture Terminal in Øygarden in Hordaland and out into open waters. The vessel is loaded with 115,000 tonnes of crude oil with destination Rotterdam. The cruise vessel, which is now without steering, hits the tanker at a speed of 10–12 knots and tears open both the bunker and cargo tanks. Oil gushes from one of the tanks onto the cruise ship. A surface fire starts around the ships and spreads to the cruise vessel. In the following 24-hour period, large quantities of crude oil leaks into the marine environment. The wind is blowing 5 m/s from the northwest and there is a 1-knot northerly sea current. The water temperature is 10°C. The air temperature is 6–8°C.

Time	Scope	Similar events
The collision occurs on a day in the middle of May at 0400 hours. The rescue efforts take 24 hours. The oil pollution control mission lasts several weeks.	The cruise ship has 2,350 people on board. The tanker has a crew of 22. The discharge consists of 100,000 tonnes of crude oil plus some bunker oil.	Costa Concordia, grounding, Italy, 2012, 32 fatalities. Scandinavian Star, fire, Skagerak, 1990, 159 fatalities. Amoco Cadiz, grounding, Bretagne, France, 1978, discharge of 220,000 tonnes of oil.



Assessment of vulnerability

Technological systems and increased management and control have strengthened the barriers against accidents at sea. Nevertheless, safety still depends on the vessel's technical condition and the crew's skill and abilities. The Norwegian Coastal Administration's maritime safety analysis from 2014[164] concludes that the human factors play the largest role in causal explanations for accidents. Navigation mistakes, errors of judgement and breaches of procedure are important subcategories. The safety culture on board is a major underlying factor. Challenging external factors such as poor weather, currents, strong winds, high waves and poor visibility also play a part.

An accident involving a large cruise ship or a tanker would significantly challenge society's emergency response resources. Cruise ships can carry several thousand passengers and rescue efforts can be highly demanding in the event of a shipwreck. The same applies to large discharges of oil in the event of a tanker shipwreck. Besides the direct effects of such an incident on the marine environment, large spills of oil into the sea would also cause problems for fisheries and the aquaculture industry in the polluted area.

Assessment of likelihood

The likelihood of a collision between an oil tanker and a fairly large passenger ship has been assessed, with the discharge of approximately 100,000 tonnes of crude oil in the area in question. The likelihood is estimated at 0.1 per cent a year. The likelihood of this incident occurring is 10 per cent in a 100-year period. In Analyses of Crisis Scenarios, this assessment is defined as *low* likelihood.

A similar incident could occur in other locations along the coast that are plied by tankers and cruise vessels. Areas that stand out include the Oslo Fjord, Kårstø/Boknafjorden in Rogaland County and the area around Melkøya/Hammerfest in Finnmark County. No calculations have been made of how likely a vessel collision such as the one described in the scenario is on a national basis, but it is assumed that this is around 20 per cent in a 100-year period, i.e. within the category defined as *low* in Analyses of Crisis Scenarios.

Generally, the likelihood of a collision at sea is higher than the likelihood of a specific collision between an oil tanker and a cruise ship. Accidents such as grounding involving a cruise vessel or a tanker, are also more likely and could also have serious consequences.

Assessment of consequences

The events in the scenario would primarily threaten the societal assets Life and health, Nature and culture, and Economy.

The overall consequences have been assessed as large.

Life and health

Overall, it is assumed that the collision scenario would result in 60 fatalities, generally caused by fire and smoke inhalation injuries. The number of serious injuries and ill people as a direct or indirect consequence of the collision is assumed to be in the order of 200. Smoke inhalation injuries will be the most dominant cause of injuries and illness. The assessments are based on lessons learned from, among others, the Scandinavian Star accident. The number of fatalities and ill/injured people would primarily depend on the scope of the fire on the cruise ship.

The consequences with respect to both fatalities and serious injuries and illness have been assessed as medium.

Nature and culture

The consequences for nature and the environment will depend on the type of oil that is leaked, weather conditions, and how much oil will be collected in the space of the first few days. Approximately 1,000 kilometres of Western Norway's coastline would be contaminated, and this would have negative environmental effects lasting many years. Seabirds, fish and other wildlife would suffer.

The consequences with regard to long-term damage to the natural environment have been assessed as large.

Economy

The overall economic losses are assumed to be substantial. Direct costs are connected to the loss of cargo and ships. The value of the oil cargo is around NOK 200 million. The tanker is regarded as a total wreck, while the cruise vessel experiences major damage.

[164] *Norwegian Coastal Administration Maritime Safety Analysis 2014. Final Report.*

The total damage is estimated at NOK 5 billion. It is difficult to estimate the costs associated with the clean-up. The total direct losses of this incident have been estimated to be in the range of NOK 6–8 billion.

Disruption and a halt to fishing and aquaculture would cause large indirect losses. A possible long-term loss of reputation with respect to both tourism and the fishing industry would also be of significance for earnings. It is very difficult to quantify the losses, but it has been set at NOK 5 billion. The uncertainty associated with the economic losses, and especially the indirect one, has been assessed as large.

Both the direct and indirect economic losses would be large.

Societal stability

The incident is dramatic, and managing it would be a long lasting effort. The scope of the discharge and the large number of people that would have to be rescued from the ships indicates that the media coverage would be extensive. The public could be expected to react strongly and questions would be asked about maritime safety and oil pollution control preparedness. It is assumed that the public and people directly and indirectly affected would expect the authorities to be prepared to handle this type of incident.

The consequences with respect to social and psychological response would be expected to be large.

It may be necessary to evacuate a smaller number of people from their homes for a shorter period of time. The discharge would have consequences for maritime traffic in the affected area.

The consequences in the area of stress on daily life would be expected to be very small.

Assessment of uncertainty

The key assumption in the assessment of likelihood is the fact that it involves a collision between two specific types of vessels, a cruise ship and a large tanker. The volume of the discharge, the oil's properties, weather and wind conditions, and the development of the fire would be crucial to the outcome. Given this, the sensitivity of the results has been assessed as medium.

In general, a lot of data is available about accidents at sea and the consequences of oil spills. One exception to this is the indirect economic consequences of oil spills in coastal zones, e.g. in the form of lost earnings for the tourism industry. No significant disagreements between the experts were noted in the work on the analysis, either with respect to the likelihood of such an incident or its possible consequences. The uncertainty associated with the knowledge base has, therefore, been assessed as low. The overall uncertainty (knowledge base and sensitivity) has been assessed as *medium*.

Possible measures

Overall, a number of measures have been implemented to strengthen preventive maritime safety in recent years. These include route-related measures outside territorial waters, the mandatory use of pilot in Svalbard waters, expanded surveillance of maritime traffic, the SafeSeaNet reporting system, the new pilot exemption certificate scheme, new marking and fairway improvements.

The Maritime Safety Analysis, which the Norwegian Coastal Administration submitted to the Ministry of Transport in 2014, particularly points out the challenges the expansion of cruise ship traffic in Arctic areas constitutes. In addition, one recommends:

- paying particular attention to areas that, over time, have a high incidence of groundings and collisions
- particularly focusing on the coast of Western Norway and the Oslo Fjord where the likelihood of incidents involving discharges of oil or chemical products, and accidents involving cruise vessels and fatalities is greatest
- paying greater attention to cruise ship traffic, which has grown strongly in recent years
- prioritising mapping the areas around Svalbard that are plied by cruise ships
- paying greater attention to the human factors behind accidents – a large proportion of the accidents are caused by such factors and this proportion has been increasing over time
- ensuring that the pilot scheme helps to improve the skills of bridge crews. The pilot should supplement rather than replace them.
- conducting more thorough investigations of the underlying causes of accidents

In 2015, the Norwegian Coastal Administration conducted an emergency preparedness analysis based on this scenario as well as the Oil and Gas Blowout scenario. The analysis is discussed in more detail under the latter scenario.[165] ◎

[165] *"Beredskapsanalyse. Verstefallshendelser akutt forurensing, vurderinger og anbefalinger", Norwegian Coastal Administration 2015.*

TABLE 21. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario			◎				10 percent likelihood.
Similar scenario on a national basis			◎				20 percent likelihood.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities			◎			60 fatalities as a direct or indirect consequence.
	People affected by serious injuries and illness			◎			200 injuries or ill people as a direct or indirect consequence.
Nature and culture	Long-term damage to the natural environment				◎		1,000 km of polluted coastline, lasting more than ten years.
	Irreparable damage to the cultural environment	◎					Insignificant.
Economy	Direct economic losses				◎		NOK 6–8 billion.
	Indirect economic losses				◎		NOK 5 billion.
Societal stability	Social and psycho-logical response				◎		Difficult to avoid, very extensive spill and large number of people involved.
	Stress on daily life	◎					The evacuation of a few people may be necessary. The sailing route may be closed for short periods.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎		Large consequences overall.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Medium uncertainty.

SCENARIO

13.2 Tunnel fire

A tunnel fire is an event with a potential to cause a major road traffic disaster. Norway has more than 1,100 road tunnels, 500 of which are longer than 500 metres. On average, there are two tunnel fires every month. 40 per cent of the tunnel fires occur in 4 per cent of the tunnels, especially in the steep, subsea tunnels. One common cause of fire is a heavy goods vehicle experiencing technical problems.[166]

The scenario analysed is a large lorry fire in a subsea tunnel. The analysis was originally conducted in 2014 and updated in 2018. The risk analysis is described in more detail in a separate subreport.[167]

Course of events

A lorry loaded with timber catches fire after colliding with a car one kilometre inside the east entrance of the Oslo Fjord tunnel. A total of 60 people are inside the tunnel when the fire starts and must evacuate. The fire service's efforts primarily start from the east side (Drøbak) and the fire ventilation pushes the smoke westwards, filling most of the tunnel with smoke. The structure and technical installations sustain considerable damage and the tunnel has to be closed for one month for repairs. Road diversions with longer journey times.

Time	Scope	Similar events
A Thursday afternoon in August. The lorry is engulfed in flames within a few minutes and burnt out after an hour.	Fire heat output is 170 megawatts (MW). Heat from the fire reaches 1 000 degrees Celsius and the tunnel is filled with toxic fumes.	• Fire in Gudvanga Tunnel in Sogn og Fjordane 2013 had a heat output of 30–40 MW. 88 persons were evacuated out of the tunnel in the course of two hours and 66 persons were treated for smoke inhalation injuries. • Fire in the Oslo Fjord Tunnel between Hurum in Buskerud and Drøbak in Akershus in 2011 had a heat output of 70–90 MW. 25 road users escaped by themselves and 9 were evacuated by a rescue crew after two hours. The fire was caused by engine problems in a lorry loaded with paper. • Fires in the Mont Blanc Tunnel on the border between France and Italy in 1999 and in the St. Gotthard Tunnel in Switzerland both had an estimated heat output of over 200 MW. A total of 39 and 11 human lives respectively were lost. In both disasters, heavy vehicles were involved.

[166] *Institute of Transport Economics report 1205/2012, Vehicle fires in Norwegian road tunnels 2008-2011.*
[167] *DSB (2014). Risk analysis of tunnel fires – partial report to the National Risk Analysis.*

Assessment of vulnerability

Long, single-bore mountain tunnels, very busy twin-bore tunnels and steep single-bore subsea tunnels are the most fire-prone tunnels. There are a total of 67 such tunnels in Norway. While they only represent 7 per cent of all road tunnels, they account for more than half of all road tunnel fires in Norway that have occurred in the last few years. 30 of these 67 road tunnels are subsea tunnels.[168]

The length and gradient of the Oslo Fjord Tunnel makes it particularly vulnerable to fire. The drop in the tunnel down to its lowest point can cause the brakes and engines of heavy goods vehicles to overheat. The length of the tunnel makes both evacuation and rescue difficult. The Oslo Fjord Tunnel also has just one bore. This means head-on collisions are possible, traffic in both directions are exposed to any smoke and that there is no opportunity to escape to another tunnel bore.

Self-rescue is the principle for evacuation in road tunnels.[169] Road users must get out either on foot or in their own vehicle. The general rule for fire ventilation is that the direction of draft should provide fire crews with 'fresh air' behind them so they can walk into a smoke-filled tunnel. In the Oslo Fjord Tunnel, this means that the smoke is ventilated westwards since the fire service will arrive from the east. In the event of a fire near the eastern tunnel entrance, this means that most of the tunnel will quickly fill with smoke.

Assessment of likelihood

The number of bores, length and gradient affects the likelihood of a fire in the Oslo Fjord Tunnel. The data on fires in road tunnels in Norway and the rest of Europe also provides a basis for assessing likelihood based on statistics. A 170 MW fire in precisely the Oslo Fjord Tunnel has been assessed as having a likelihood of 0.5 per cent per year and 40 per cent in a 100-year period. This is defined as *moderate* likelihood on the ACS scale.

There are around 30 other subsea tunnels that represent a similar fire risk in Norway, so the transferability of the analysis to other tunnels is high. For all the tunnels as a whole, there is an almost 100 per cent or *very high* likelihood of a similarly large fire occurring in a 100-year period.[170]

Assessment of consequences

The scenario Tunnel Fire will affect three out of five societal assets defined in ACS: Life and health, Economy and Societal stability. Overall, the consequences have been assessed as *small* on the scale used in ACS.

Life and health

Given average daytime traffic, there would be 60 road users inside the tunnel when the fire starts. 50 of these would be on the west side of the fire since it starts near the eastern tunnel entrance. They would have up to six kilometres to cover to evacuate, which could take 1.5 hours on foot. The fire ventilation would draw the smoke westwards since rescue efforts from the east are prioritised. The smoke would move at a speed of around 10 kmph (3 m/s) and it is assumed that it would catch up to around half of the evacuees, approximately 25 people.

It is assumed that five of these would die from smoke poisoning and that a further five would live shorter lives due to chronical respiratory disorders. It is assumed that ten people would sustain serious smoke injuries. It is assumed that in the aftermath a further five people would suffer from psychological disorders such as post-traumatic stress.[171]

The consequences for life and health have been assessed as small on the scale used in ACS.

Nature and culture

Heavy smoke may blacken the buildings and nature outside the tunnel, but it will not yield lasting damage.

Economy

The structure and technical equipment would sustain considerable damage and the tunnel would have to be kept closed for around one month because of repair work. It is estimated that the direct economic costs would be NOK

[168] *Directorate of Public Roads' tunnel database.*
[169] *Public Roads Administration "Handbook 021 Road Tunnels", 2010.*
[170] *A more detailed description of the calculations can be read in the 'Fire in Tunnel' subreport.*
[171] *Around 25% of those directly involved in life-threatening situations are thought to suffer post-traumatic stress (e.g. see report no. 5/2017 on the Scandinavian Star accident from the Norwegian Centre for Violence and Traumatic Stress Studies).*

70–80 million due to the need for cleaning soot damage and repairing and renewing the road surface and equipment (cables, fans, pumps, etc.), as well as securing the rock and new shotcrete after the rock has been exposed to extreme heat.

The indirect economic losses would primarily consist of higher transport costs for businesses and socio-economic costs due to diversions of traffic via Oslo or the Horten–Moss ferry increasing the journey time (0,5–1 hour delay). With 7,400 vehicles every 24 hours and an average hourly cost of NOK 200,[172] the delay costs would amount to around NOK 60 million in a one-month period. In addition to this come extra vehicle and fuel costs, due to diversions, of around NOK 18 million. The indirect economic losses would total around NOK 80 million.

The economic losses are regarded as very small on the ACS scale.

Societal stability

A major fire in the Oslo Fjord Tunnel would make a large proportion of road users fearful and anxious about driving through this and other subsea and long tunnels. Norwegian and Swedish surveys show that around 30 per cent of road users feel anxious about driving in tunnels in any case, and a major fire would exacerbate this anxiety.[173]

Being caught in smoke with no chance of escape is a frightening experience. Several kilometres is a long way to walk in a steep, smoke-filled tunnel. The road users' expectations of being rescued by the fire service in the event of a fire in a tunnel might be unrealistic. A tunnel fire especially impacts vulnerable groups because the sick (particularly those with respiratory problems), elderly, children and people with physical disabilities have the greatest difficulty evacuating.

The scenario would result in a medium social and psychological response.

Closure of the Oslo Fjord Tunnel implacates in diversions via Oslo or the Moss-Horten ferry route. This lengthens journey times by 0.5-1 hour. It is estimated that the delays would affect around 5,000 road users over a month. However, this is regarded as a limited impact on a relatively small section of the population.

The scenario would result in a small amount of stress on daily life.

Assessment of uncertainty

A tunnel fire is a known and researched phenomenon in both Norway and other countries. Data and experience from a number of smaller tunnel fires exist, which includes the analysed tunnel. However, the assessment of likelihood is sensitive to the assumption that 3 per cent of all tunnel fires are of at least 170 MW. The assessment of likelihood is therefore somewhat 'theoretical' and uncertain.

The assessment of the consequences is more experience-based and certain. It would take major changes in the analysis's assumptions (tunnel design, traffic volumes, etc.) to significantly change the consequences. Overall, the uncertainty (knowledge base and sensitivity) has been assessed as low.

Possible measures

- Subsea tunnels
  It is difficult to change existing tunnels' geometric factors (length, gradient and number of bores). These tunnels therefore have a built-in risk. The risk can partly be compensated for by the quick detection of incipient fires and good escape options for road users. Existing barriers in the Oslo Fjord Tunnel include the Traffic Control Centre's CCTV surveillance.[174] After the fire in 2011, 25 smoke-tight refuges were built in pockets in the rock with space for 20–50 people in each room.

- Fire ventilation direction
  The Traffic Control Centre knows exactly where in the tunnel a fire is, thanks to CCTV surveillance, the removal of fire extinguishers or calls from emergency stations, and could control the smoke for the benefit of road users rather than the fire service – in line with the self-rescue principle. In the emergency response plan for each tunnel, the fire services and Norwegian Public Roads Administration should assess whether the ventilation direction should be determined for each individual fire instead of being decided in advance.

- New tunnel bore
  Two tunnel bores would separate the driving directions and prevent head-on collisions. It would also provide safe escape routes to the other bore. However, as long as the gradient is the same, fires could still be caused due to heavy goods vehicles' brakes and engines overheating.

[172] *Based on figures used in, among other things, cost-benefit analyses the Norwegian Public Roads Administration (EFFEKT).*
[173] *Lauvland 1990 and SVEBEFO 1997.*
[174] *The Oslofjord Tunnel is closed by the Traffic Control Centre around 300 times a year based on, among other things, CCTV surveillance. Just 10% of closures are planned (operation and maintenance).*

TABLE 22. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODER-ATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario				◎			40 percent likelihood.
Similar scenario on a national basis						◎	100 percent likelihood.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities		◎				10 fatalities (5 directly and 5 prema-turely).
	People affected by serious injuries and illness	◎					10 smoke inhalation injuries and 5 who develop psychological disorders.
Nature and culture	Long-term damage to the natural environment						No permanent damage.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses	◎					Repairing the tunnel and technical equipment would cost NOK 70–80 million.
	Indirect economic losses	◎					Diversions would increase transport costs by around NOK 80 million.
Societal stability	Social and psycho-logical response			◎			Because of the lack of escape options it is assumed that the fire cause fear og anxi-ety among road useres
	Stress on daily life		◎				Closure of the tunnel for a month will result in delays of ½–1 hour for approximately 5,000 road users daily.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES			◎				Small consequences overall.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY			◎				The uncertainty has been assessed as small.

PHOTO BERIT ROALD / NTB SCANPIX

SUPPLY FAILURES:
Drug shortages are a growing global problem and reports of drug delivery failures in Norway have multiplied in recent years.

14

SUPPLY FAILURES

Background

The Norwegian economy is small and open. Where we can, we produce what we can using the natural resources available to us or what we can produce cheaper and better than others. Goods and services that we cannot produce competitively, we import from abroad.

Over time, society has evolved from being largely self-sufficient, via steadily increasing specialisation, to the current situation where product flow and value chains are largely global. This development has contributed to more efficient use of resources and provided economic growth in large parts of the world. However, this development has also involved increased vulnerability. From being vulnerable to fluctuations and failures in domestic production, we are now more dependent on the goods (and services) we need being available in the international market, and on international logistics systems working. Some products have long and complex value chains that are difficult to keep track of, with the risk of vulnerabilities being overlooked or underestimated.

A decrease in holding stock has been another important trend in recent decades. Holding stock ties up capital and, financially speaking, is not particularly efficient. Technological advances have provided new means of maintaining an overview of demand based on various product categories, and production can more easily be adapted to current demand. The ideal situation would be for the products to arrive in stores 'just-in-time' to prevent empty shelves. However, the reduction in holding stock has also weakened buffers against failures in production and logistics, and has therefore significantly increased vulnerability.

Globalisation does not encompass all products to the same extent. Deliveries that are linked to one's own infrastructure systems have stronger local, regional or national anchoring. Water supplies and waste water management are often performed by municipalities. Power supplies and electronic communications services are linked to national infrastructure systems, but with links to similar systems in neighbouring countries.

Agriculture on the other hand is the only sector that is shielded to some extent from international competition. This is partly justified by emergency preparedness considerations.

Risk

A supply crisis can occur due to:

- Demand shock
- Supply shortage
- Logistical failure

Today's supply and logistical systems are designed for normal fluctuations in demand. *Demand shock* occurs when there is a sudden strong increase in demand that exceeds the variations the market normally deals with. The consequence can be a shortage.[175] Examples of situations that can trigger demand shock within some goods and services categories are global epidemics, widespread acute refugee crises, security policy crises and war.

Supply failure occurs when the production of goods and services stops. Some goods are produced in particular regions or by a small number of producers. An inherent vulnerability exists in such a situation. Norway, not least, which has a relatively specialised production structure and is a small player in the global market, would quickly be affected by global shortages. Failures in the trade of goods and services can occur, for example, due to natural disasters in areas vital to the global market or demand shock in other parts of the world.[176]

Domestic logistical failures can occur due to damage to main road transport systems and railways connections, ports becoming unavailable or unusable, or management systems for logistics in the trading chains or at logistics operators failing. Today, trade and distribution are based to a very large degree on the continuous exchange of information via ICT. Failures in these networks would dramatically increase distribution, holding stock and purchasing costs. Supplies of products would fall quickly. In some areas, deliveries of some products might stop altogether.

Primarily, serious domestic logistical failure occur due to failures in the system element of logistics and in land-based transport systems. However, a crisis situation could also be caused by logistical failure in our neighbouring countries. There is an increasing trend towards direct distribution from other European countries to the Norwegian market.[177]

The vulnerability of supplies due to infrastructure systems can also be assessed based on a combination of demand shock, supply shortage and logistical failure. Electricity is a product that is used at the same moment as it is produced. In other words, the production of electrical energy must at all times match the demand. If there is an imbalance, this can have serious consequences for the entire system. Imbalances can occur due to demand shock, for example during periods of extreme cold, or as a result of supply shortage, for example due to a persistent drought resulting in the emptying of hydropower reservoirs, combined with reduced ability to import electricity from neighbouring countries. A situation in which demand shock and supply shortage occurred at the same time would be especially serious. The infrastructure dependency of these functions means that physical damage due to extreme weather and other natural events, fire, sabotage, etc., or other faults in the networks, can result in failures in larger or smaller areas.

In winter 2010/2011, power shortages almost occurred in parts of Norway. The preceding winter had been cold and dry, and, combined with low Swedish nuclear power production, this resulted in record low reservoir levels at the start of the winter. Very cold weather before New Year resulted in further reservoir drawdowns. Reservoirs were at record low levels until week 15 in 2011. However, mild weather and early snowmelt saved the situation at the beginning of April.[178]

Prevention and emergency preparedness

Both of the world wars resulted in supply challenges in Norway. Part of the reason for this was logistics failures, i.e. the free flow of traffic between Norway and the rest of the world was obstructed (World War I) or halted (World War II). Civil emergency preparedness work up to around 1990 focused on war and crises of a similar scope and severity.

The experience of previous war and blockade situations also meant that up to the end of the Cold War, supply crises were expected to last for a long time and most often result from being physically cut off from resources and markets, or a genuine shortage of goods.[179] Since 1990, the Cold War arrangements have gradually been reduced and discontinued. Even though the level of tension in Europe has again risen following Russia's annexation of the Crimea in 2014, blockades of imports into Norway are not regarded as part of the threat picture.[180]

Supply crises can generally be prevented by holding buffer stocks, and redundancy, by establishing alternative solutions in the area of logistics. Enterprises that import important products can, to the extent possible, also spread orders across more suppliers or suppliers from more regions in order to reduce vulnerability. Pre-defined rationing procedures for products no longer exist in Norway, although some of the legal authorities have been maintained.[181]

---

[175] *Act on Business and Industry Preparedness (Business and Industry Preparedness Act).*
[176] *Ibid.*
[177] *Ibid.*
[178] *Power situation winter 2010/2011, NVE 2011.*
[179] *Analysis of risk and vulnerability in the Norwegian food supply, DSB 2017.*
[180] *See the discussion under the Aggression by foreign state risk area.*
[181] *Act on Business and Industry Preparedness (Business and Preparedness Act).*

Procedures that were in place during the Cold War were discontinued in the 1990s. In the event of electrical energy being rationed, means of, and requirements for, prioritisation been specified in the Electricity Rationing Regulation, e.g. zone-by-zone rolling disconnections.[182]

Enterprises with responsibility for critical societal functions have an independent responsibility to ensure they can maintain services and supplies to meet needs at all times.[183] Continuity planning must be based on an analysis of one's vulnerabilities, including vulnerabilities associated with a lack of access to important input factors such as energy, electronic communications, goods that are used in production and spare parts. Vulnerability reduction measures must be implemented based on the analysis results. Enterprises that are critically dependent on electricity to operate must have a sufficient backup power supply of their own.

The purpose of the Business and Industry Preparedness Act is to alleviate the supply-related consequences of crises by strengthening the supply of goods and services and by ensuring necessary assignment of priorities for, and redistribution of, goods and services through collaboration between public actors and business operators. However, attempts must be made to resolve the challenges via commercial schemes and voluntary cooperation before the public authorities use legal authorities that the Act provides in relation to regulation.[184]

The Ministry of Trade, Industry and Fisheries has been assigned important responsibilities concerning the security of supply in areas such as food, fuel, building and construction services, and shipping. In the event of a supply crisis that affect households, municipalities could be assigned a central role with responsibility for social preparedness.[185]

The food preparedness committee is an advisory body for the Ministry of Trade, Industry and Fisheries in preparedness planning and a forum for sharing information about matters of significance to food supplies in the country. The body is also intended to function as the Ministry of Trade, Industry and Fisheries' crisis management organisation in the food sector. The committee comprises representatives of the food distributors. The Ministry of Trade, Industry and Fisheries has established contingency stocks of food. The stockpiles are located in various parts of the country and include dried and canned foods. The Ministry of Trade, Industry and Fisheries also has agreements with the food preparedness committee concerning building up larger stores of food when needed.[186]

A national drugs preparedness committee has been established, which must help to ensure good routines for cooperation and communication between the operators involved in drugs preparedness. The national committee's members represent all of the actors involved in the value chain. The regional health authorities have local drugs committees that include representatives of hospital pharmacies.

Prior to 2015, the Norwegian Directorate of Health administered national contingency stocks of medicinal products, both for the specialist and the primary health services. However, it was neither practical nor economically feasible to have stocks of medicinal products in Norway that covered all possible shortage situations. The discontinuation of the national contingency stocks resulted in regional health authorities being assigned greater responsibility for preparedness with respect to drugs used in the specialist health services.[187]

The health authorities have an agreement with a wholesaler for delivery of drugs. Pursuant to the agreement, the wholesaler must maintain an expanded inventory of drugs that are listed on the hospital pharmacies' critical list, a total of 660 specific medicines. In relation to the primary health service, drugs wholesalers that deliver to pharmacies are required to hold a contingency stock of important drugs equivalent to two months of ordinary sales.[188]

The Norwegian Water Resources and Energy Directorate (NVE) is responsible for coordinating emergency preparedness planning and shall manage the nations's power supply system in emergency situations and in wartime. For this purpose, a nationwide organisation, the Power Supply Preparedness Organization (KBO), has been established. The KBO consists of NVE and the undertakings that are in charge of the power supply system. Every unit in the KBO has an independent duty to ensure effective security and emergency preparedness, and to implement measures to prevent, reduce and manage the effects of extraordinary situations.[189] Plans must be drawn up for the management of a situation in which power supplies fail, which includes plans for rationing.

[182] *Regulations relating to the planning and implementation of the requisition of power and enforced supply restrictions during power rationing.*
[183] *"Vital functions in society", DSB, 2017.*
[184] *Ibid.*
[185] *Act on health and social preparedness.*
[186] *Analysis of risk and vulnerability in the Norwegian food supply, DSB 2017.*
[187] *Report to the Storting (white paper) No. 28 (2014–2015) Medicinal Product Policy.*
[188] *"Risikoanalyse av legemiddelforsyningen", DSB 2018.*
[189] *Regulation on prevention safety and preparedness in energy supply.*

SCENARIO

14.1 Long-Term Power Rationing

All critical societal functions depend on stable power supplies to a greater or lesser extent. Unlike in other countries, in Norway a substantial proportion of building heating is based on electrical energy. Therefore, power outages are events that could have major consequences. In 2010, an analysis was conducted of a situation involving long-term power rationing in Central Norway. The analysis was updated in 2018.

Course of events

Two seasons with little precipitation have resulted in generally low water levels in reservoirs. Domestic generation has been reduced as a result of earlier incorrect estimates of water levels. Opportunities for importing power from abroad are very limited due to a halt in Sweden nuclear power production and cable rupture. An early and cold winter results in heavy consumption just before Christmas.

The period from 1 March is characterised by low average temperatures. Extreme cold in the first part of the month is followed by a normalisation of temperature conditions. From 1 March, all power consuming industry is ordered to disconnect, while quota rationing is also introduced. From 15 March, zone-by-zone rotating disconnections are implemented. With the exception of prioritised enterprises, subscribers receive access to electricity for a period of four hours, twice a day.

Time	Scope	Similar events
The measures are implemented from 1 March. The rationing ends on 15 May.	The rationing applies to Elspot area[190] NO3, Central Norway, i.e. Trøndelag, Møre og Romsdal, and parts of Sogn og Fjordane, Oppland and Hedmark.	• Difficult power situation with low water levels in reservoirs, winter 2010/11 • Power outage in Steigen Municipality in Nordland, 24–30 January 2005

[190] *As of 2018, Norway has been divided into five so-called 'Elspot areas'.*

Assessment of vulnerability

The security of electricity supply is generally high in Norway. In a normal year, delivery reliability is more than 99.98%.[191] Internationally, Norway is regarded as the best in the world in the area of energy access and reliability.[192]

In 2015, 96% of Norwegian electricity was produced by hydropower plants.[193] A greater ability to transfer power between regions and connect to power systems in neighbouring countries means Norway's dependence on sufficient precipitation and regional catchment has been reduced.

Society is highly vulnerable to power outages. All critical societal functions depend on electricity to function, although far from every enterprise with responsibility for critical services and deliveries has access to backup power sources. In the event of rationing in terms of zone-by-zone disconnections, the available energy will be prioritised based on life and health considerations, vital societal interests and business, and affected economic interests.[194] A substantial amount of the electricity consumed in Norway is used for heating. More than 20% of homes in Norway are completely reliant on electricity for heating.[195]

Assessment of likelihood

Given this, the likelihood of the specific event in Central Norway occurring has been assessed as being in the lower half of the *very low* category (2 per cent likelihood in a 100-year period). Statnett believes that the likelihood of rationing occurring in one or more regions is between 5–50 per cent in a 50-year period.[196] However, this applies to rationing in general: shorter term and less extensive rationing than that described in the scenario is far more likely than what is described here. The likelihood of the specific scenario occurring in one of the five electricity regions is estimated to be 10 per cent in a 100-year period, or *low*.

Assessment of consequences

The societal consequences of the given scenario are assessed as *large*. The scenario will primarily threaten the societal assets Life and health, Economy and Societal stability.

Life and health

Inadequate means of maintaining a normal indoor temperature will be very serious in the winter, especially for the elderly or ill people. More fires would occur due to more widespread use of open fires and more road traffic accidents would occur due to the lack of lighting. In addition to this, the accidents that do occur would have more serious consequences due to the failure of base stations in the mobile phone networks and the subsequent difficulty getting through on emergency numbers. The direct and indirect fatalities are assumed to reach a total of 100 overall. The number of serious injuries and ill people as a direct or indirect consequence of the rationing is assumed to range from 300 to 500. The uncertainty associated with the estimates is assessed as large.

The consequences with respect to fatalities would be medium, and large with respect to serious injuries and illness.

Economy

The direct losses associated with the event would be due to a higher number of fires because of more widespread use of open fires. The material losses associated with, for example, water and frost damage, must also be included in the calculations. Technical equipment can also be damaged by power outages. The losses are estimated to be in the range of NOK 100–150 million.

The direct economic consequences would be small.

It is estimated that the indirect losses due to the event would be high, especially for industry and business, as well as for the power industry itself. It is estimated that the total indirect economic losses would be NOK 10-20 billion.

The indirect economic consequences would be large.

Societal stability

Hospitals and certain other critical societal functions are given priority, while other customers are given access to electricity for a very limited period of the day (2 x 4 hours).

---

[191] *"Avbrotstatistikken 2016", NVE Report 43/2017.*
[192] *Proposition 1 S (2017–2018) 1 S (2017), Ministry of Petroleum and Energy.*
[193] *Proposition 1 S (2017–2018) 1 S (2017), Ministry of Petroleum and Energy.*
[194] *Regulations governing the planning and implementation of requisitioning of power and enforced reductions in supply in connection with electricity rationing (Electricity Rationing Regulation).*
[195] *"Oppvarming i boliger", NVE Report 85/2014.*
[196] *"SAKS 2014. Gjennomgang av og behov for SAKS-tiltak", Statnett 2014.*

Zone-by-zone disconnections have different effects on subscribers who should generally be treated equally. Subscribers in the same zone as a prioritised enterprise (hospital, waterworks, etc.) would benefit from this. This, together with the scope and duration of the rationing, would result in reactions such as anxiety and frustration.

Vulnerable groups would be especially vulnerable, and this might be regarded as socially unacceptable. It is assumed that both business and industry expect that it should be possible to avoid power rationing, and the incident may reduce confidence in authorities.

Overall, the social and psychological response would be large.

Disconnecting the power will have large consequences for a number infrastructures and societal functions, and it will have substantial effects on daily life for the population. In particular, ICT systems, including payment terminals and ATMs, will be hard hit. Cooling systems, fuel pumps, signalling systems for trains and road traffic are examples of other systems that would be impacted to a greater or lesser extent. It is estimated that several hundred thousand people will experience significant problems in several of these areas while rationing takes place. The uncertainty associated with these assumptions has been assessed as large.

Electricity rationing would cause a very large amount of stress on daily life.

Democratic values and capacity to govern

The power rationing scenario would entail a need for very extensive and long-term crisis management. Dealing with this would require such a large amount of resources that it would, to some degree, impact other functions of county governors and municipalities.

Nonetheless, the consequences for the capacity to govern are regarded as small since the event does not cover the entire country and there are established procedures for how power rationing should be implemented.

Assessment of uncertainty

The knowledge base for return periods for various climate phenomena is very good. A lot of historical data about precipitation, temperature and reservoir inflow is available. The knowledge about reliability of power generation in our neighbouring countries and power networks is good.

Given this, the knowledge base used to assess the likelihood of this adverse event occurring is regarded as very good and the uncertainty has therefore been assessed as small.

Plans and procedures for zone-by-zone rotating power disconnections are in place. As such, this is a situation we know a lot about, even though no such event has occurred in modern times in Norway. The immediate consequences are relatively predictable, although greater uncertainty exists about the consequential effects. The interdependencies between different societal functions are numerous and difficult to maintain a complete overview over. However, no major differences of opinion between the experts were noted during the analysis seminar. Overall, the uncertainty associated with the assessment of consequences has been assessed as medium.

The likelihood of the event occurring is sensitive to changes in the assumptions regarding water reservoir levels and the ability to import power from abroad. The consequences are sensitive to changes in temperature during the period of the event and the duration of rationing. Overall, the sensitivity of the results has been assessed as medium. Given this, the overall uncertainty has been assessed as *medium*.

Possible measures

In Report to the Storting (white paper) No. 25 (2015–2016) Power to Change. – Energy Policy Towards 2030, the Government points to a series of measures for strengthening security of supply through improvements to the power system. In general, measures for reducing the likelihood of the need for power rationing arising include:

- increased generation capacity
- enhancing the capacity of the domestic transmission network and with respect to other countries.

The consequences of any shortage situation can be reduced by:

- more enterprises that are critically dependent on electrical energy acquiring backup power sources
- households' own preparedness measures
- exercises at a local and regional level. It is important that the municipalities and county governors are aware of how demanding managing a long-term rationing situation can be.

The introduction of advanced metering system (AMS) provides more opportunities for controlling power consumption in a shortage situation through active use of the price mechanism and through a better designed and targeted form of rationing. ◎

TABLE 23. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario		◎					2% likelihood of occurring in a 100-year period.
Long-term power rationing somewhere in the country.			◎				10% likelihood of occurring in a 100-year period.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities			◎			Up to 100 fatalities as a direct or indirect consequence.
	People affected by serious injuries and illness				◎		300–500 injuries or ill people as a direct or indirect consequence.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses		◎				NOK 100-150 million due to the higher number of fires and road traffic accidents, and some damage to technical equipment.
	Indirect economic losses				◎		NOK 10–20 billion.
Societal stability	Social and psycho-logical response				◎		Very large scope and long duration, vulnerable groups are exposed, responsibility questioned, reactions such as anger and mistrust.
	Stress on daily life					◎	Critical services and deliveries are hit hard; long duration.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern		◎				Places the governing system under strong pressure nationally, as well as region-ally and locally. Disappearance of critical societal functions.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎		The societal consequences have been assessed as *large*.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed as *medium*.

SCENARIO

14.2 Global Grain Production Failure

Stable, safe access to basic food is important from a public safety perspective. In 2016-2017, the DSB conducted a risk and vulnerability analysis of Norwegian food supplies on behalf of the Ministry of Trade, Industry and Fisheries and the Ministry of Agriculture and Food. The analysis is documented in a separate report.[197] The analysis includes a scenario involving failure in the supply of food grain in the global market combined with crop failure in Norway. The scenario has been adapted slightly so it can also be included in Analyses of Crisis Scenarios.

Course of events

Little precipitation in the monsoon season results in the wheat crops in India failing and also impacts Chinese crops. At the same time, a large proportion of the winter wheat in the countries around the Black Sea is destroyed in the spring due to mild weather followed by a cold front. Because of this, Russia and Ukraine impose export restrictions. In the early summer, a drought strikes North America and lasts throughout the summer.

This negative development is exacerbated by the Western European wheat crop failing due to a heat wave and drought. The drought that strikes the European wheat crop also impacts crops in the Central Europe region. In addition to this, heavy precipitation during the harvest season results in poor quality grain. Domestic production this year only covers 10% of the domestic need for food wheat.

Time	Scope	Similar events
The crisis starts in autumn and develops during the winter. It lasts until the following autumn.	The scenario describes a very extensive and simultaneous failure in the production of grain and feed crops throughout the world.	• The international food crisis in 1972–1974, which resulted in a sharp reduction in grain stockpiles and strong rises in market prices. • Reduced crops of rice, wheat, maize and soya in 2007 and 2008 resulted in significant price increases for important agricultural products. • Failing crops in Russia and Eastern Europe in 2010 and 2011 led to price increases for grain.

[197] *Analysis of risk and vulnerability in the Norwegian food supply, DSB 2017.*

Assessment of vulnerability

The vulnerability in the supply of food grains is linked to our dependence on imports. Even in good years, we rely on well-functioning trade and logistics systems. This vulnerability is reduced by domestic production of food. The share of food grain consumption produced in Norway can vary a lot from year to year due to weather conditions. In 2016 the share was 58 per cent, compared with 67 per cent in 2015 and 48 per cent in 2014. In 2012, the share fell to 19.3 per cent.[198]

Grain is a staple food and failures in the supply of food grains will have noticeable consequences for the public. However, households can replace grain products with other foods. Therefore, supply shortages of grain would not necessarily have significant nutritional consequences.

Assessment of likelihood

The design of the scenario and assessments of likelihood were largely based on a British study of how climate change and extreme weather may affect crop failure frequency, and how this would affect the global market.[199]

The scenario is based on simultaneous crop failures in India, China, the Black Sea region, North America and Western Europe in the same year, and the British study describes this as a 100-year event given the current climate picture. Poor food grain crops in Norway occur around every fifth year. Given this, it has been estimated that the analysed scenario, with the current assumptions, has an annual likelihood of occurring of 0.2 per cent. The likelihood of the scenario occurring in a 100-year period has been assessed as 20 per cent. The likelihood is therefore *low* based on the criteria used in ACS. As a consequence of climate change, the likelihood of the event occurring in a 100-year period could increase to 60 per cent in the space of a few decades.

Assessment of consequences

The way the global trading systems work is that an imbalance between supply and demand will be equalised by price formation in the market. Failing crops on a global scale would result in grain prices rising in the global market. As long as the global market works, an event such as this would primarily have economic consequences in Norway.

The overall consequences have been assessed as very small.

Life and health

The global shortage situation would not lead to a shortage of food in Norway. Even if there were some changes in the range of products available, this could be handled by consumers through alternative food options and changing their diet. In Norway, individual households spend a relatively small proportion of their income on food and therefore have a certain buffer against price rises.

The very poor grain harvest in Eastern Norway included in the scenario would be difficult to cope with for individual farmers and could have health consequences.

Overall, the event has been assessed as having very small consequences for life and health in Norway.

Economy[200]

It is assumed that the international prices would quadruple during the crisis and that Norwegian grain prices would mirror this. Just over 250,000 tonnes of food wheat are consumed in Norway a year, 40–60% of which is normally produced in Norway.

The calculations of the economic consequences are based on the consumption in Norway during the crisis year being covered by 25,000 tonnes of Norwegian produced food wheat, 125,000 tonnes of wheat that is also imported in a normal year, and 100,000 tonnes of imported wheat as a replacement for the wheat that would be produced in Norway in a normal year.

It is estimated that the total indirect economic losses for society due to higher grain prices would be around NOK 950 million. Account has not been taken of the consequential effects of price rises. No account has been taken of reduced demand for grain due to higher prices either.

The indirect economic consequences would be medium.

---

[198] *"10 facts about Norwegian agriculture", www.nibio.no, 2018.*
[199] *The study forms part of the United Kingdom's Global Food Security programme, www.foodsecurity.ac.uk*
[200] *The Ministry of Trade, Industry and Fisheries' risk and vulnerability analysis did not contain any calculations of the economic consequences. These calculations have therefore been made by the Norwegian Agriculture Agency afterwards.*

Societal stability

Although increased prices for flour, bread and other foods may affect vulnerable groups, the effects would be marginal. The public also have substantial room for action to cope with the situation by changing their consumption patterns. The assessment is that the event would have very small social and psychological consequences for the population in general. Besides making some changes with respect to the range of products available, the stress on daily life caused by the event would be very small.

The consequences for social and psychological response and stress on daily life have been assessed as very small.

Assessment of uncertainty

The lessons learned from earlier major fluctuations in food markets provide knowledge about how the markets work in difficult situations and how flexible they are with respect to adapting.

The authorities, expert environments and organisations associated with the agricultural and fishing industries largely agree that it would take a lot for global food trade to break down.

The assessments are sensitive to the assumption that the price mechanism would ensure a balance between supply and demand. Were many more countries than just Russia and Ukraine to introduce export restrictions, the consequences of such an event would be greater than those in the analysed scenario.

A scenario involving a global crisis in food supplies lasting several years would be a much greater challenge for Norwegian food security than a one-year crisis, but given the current situation, this is a highly unlikely event. However, we cannot ignore the fact that in 15-20 years the risk may appear somewhat greater.

Overall, the knowledge base for the current situation is regarded as good, and the sensitivity of the assessments of consequences has been assessed as small. Therefore, the uncertainty associated with the assessments has been assessed as *small* with respect to both likelihood and consequences.

Possible measures

The experts who took part in the analysis work disagreed about whether the assessed risk was acceptable or not. Some thought that the likelihood of Norway being unable to obtain food grains in the global market is, as of today, so small that there is no need for special preparedness measures, while others believed that one should take into account scenarios in which this is not possible.

Based on the uncertainty associated with future developments, the risk and vulnerability analysis for Norwegian food supplies points out the following possible measures:

- Enhanced monitoring of the likelihood of a failure of international supplies.
- Study of which measures would be necessary in order to be able to re-establish food grain storage if the assessment of the need to do so changes.
- Study the potential that lies in changing production and consumption patterns in times of crisis.
- Restrictive soil protection practices ◎

TABLE 24. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario			◎				20% likelihood of the event occurring in a 100-year period given today's climate.
Transferability is not relevant							
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities	◎					Unlikely to be any fatalities as a direct or indirect consequence of the event.
	People affected by serious injuries and illness	◎					Mental stress for directly affected farmers.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses						Not relevant.
	Indirect economic losses			◎			Higher costs for consumers, losses for famers, etc. Totalling in the order of approximately NOK 950 million.
Societal stability	Social and psycho-logical response	◎					No significant social and psychological response among the public.
	Stress on daily life	◎					No significant stress on daily life.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES		◎					Very small consequences overall.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY			◎				The uncertainty has been assessed as *small*.

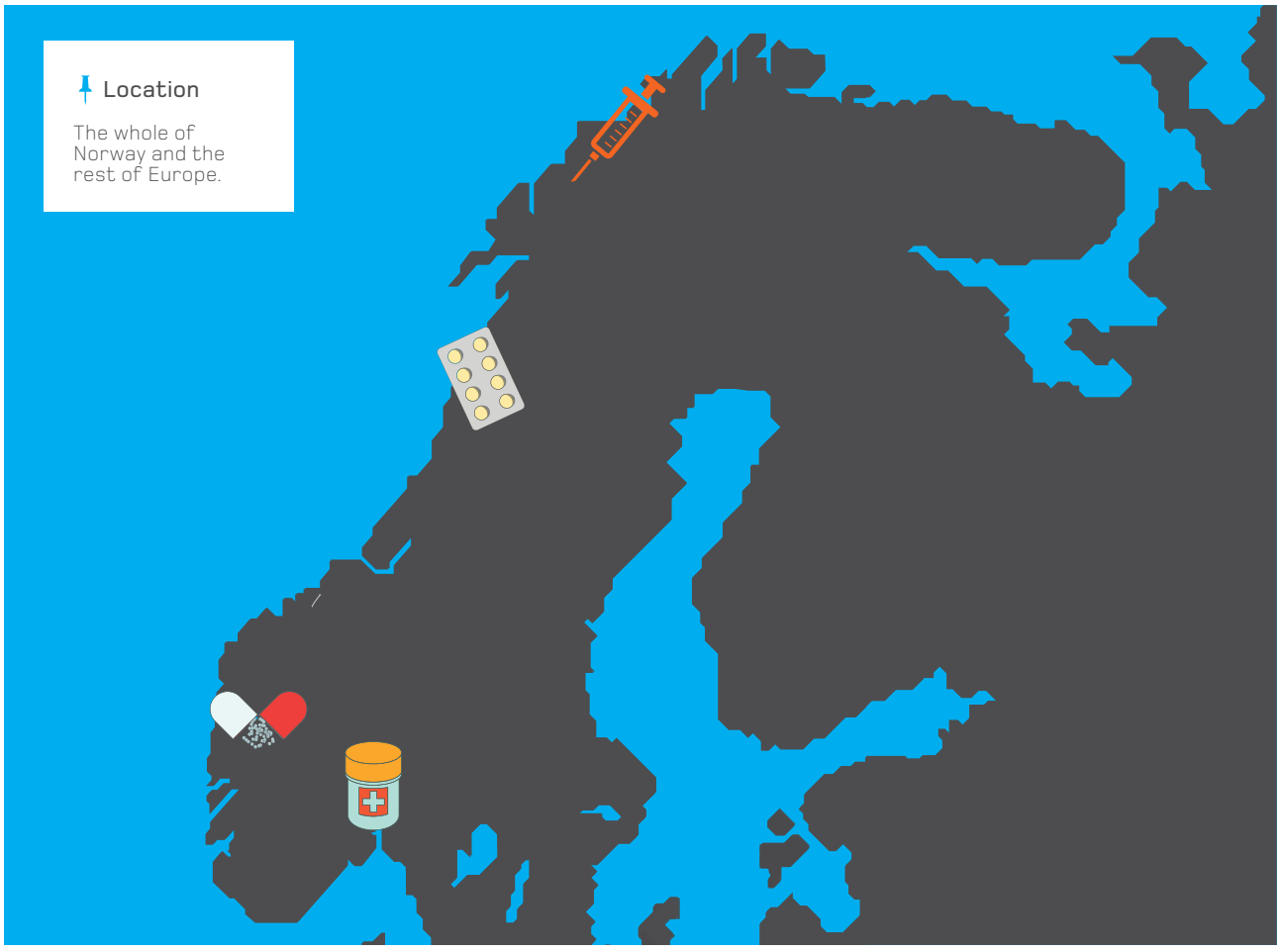
SCENARIO

14.3 Drug Shortage

Drug shortages are a growing global problem and reports of drug delivery failures in Norway have multiplied in recent years. Supply chains for drugs are long, complex and market steered, and Norway's ability to influence them beyond the country's borders is limited. The risk analysis for a drug shortage was conducted in 2017/2018 and is documented in a separate subreport.[201]

Course of events
An explosive fire occurs at a plant in Asia that produces some active ingredients for antibiotics. The owners fail to warn of the disruption to operations and the event is not noticed before a shortage of antibiotics occurs several weeks later. At the same time, one of the largest producers of insulin for Europe experiences production problems because the plant is contaminated by bacteria and has to close for a period of time. After a short while, deliveries of insulin and some types of antibiotics to pharmacies throughout Europe cease. The shortages result in hoarding and pharmacies in Norway are emptied of the drugs within a few days.

Time	Scope	Similar events
The pharmacies have no insulin or some types of antibiotics for three weeks.	The whole of Europe is impacted by the supply failure, and large patient groups will experience a shortage of vital medicines. In Norway alone, around 30,000 people have type 1 diabetes and rely on insulin.	A drugs plant in China suffered a fire in 2016. It took six months before the Norwegian authorities received confirmation that this was the cause of the subsequent shortage situation.



[201] *Report "Risikoanalyse av legemiddelmangel", DSB, 2018.*

Assessment of vulnerability

Production and supply lines in the global drugs industry are long and complex. The active ingredients for drugs are largely produced in Asia, and China and India are the largest global exporters. The pharmaceutical industry is steered by the market and characterised by secrecy. The entire logistics chain heavily depends on ICT, and deliveries are based on the 'just-in-time' principle throughout the chain.

The Norwegian market is small and a low priority for international pharmaceutical companies. We have limited stocks of critical drugs at wholesalers and marginal domestic production. Therefore, Norway is completely reliant on the proper functioning of the pharmaceutical industry, and is highly vulnerable to any protectionist measures. There are no pre-defined guidelines for distributing and prioritising drugs between patients and patient groups in the event of delivery failures. Shortages have up to now been resolved through voluntary schemes, but these may be insufficient in the event of a more serious crisis.

The Norwegian Medicines Agency registered 358 shortage situations in Norway in 2017, more than twice as many as in 2016. In the last few decades, the number of shortage situations has multiplied tenfold.

Assessment of likelihood

The Norwegian authorities have a national preparedness scheme in place for drug shortages, but little control over international production and logistics. The stocks held by wholesalers are a buffer in case of supply failures, which give the authorities a bit more time to find alternative drugs in the event of short-term shortage situations. However, these stocks are not an answer to long-term production problems. The preconditions for failures in drug supplies to Norway have therefore been assessed as largely being present. The steady increase in registered shortages in Norway from year to year supports this contention.

The annual likelihood of a drug shortage such as the one described in the scenario has been assessed as 1–2 per cent. The likelihood of the scenario occurring in a 100-year period has been assessed as *high* (75 per cent). The likelihood of serious shortages involving other types of drugs has been assessed as *very high* in a 100-year perspective (more than 90 per cent likely). However, the scope and severity would depend on which specific drugs were involved.

Assessment of consequences

Overall, the consequences of the drug shortage in the scenario have been assessed as *large* compared with other scenarios in ACS. The number of fatalities and seriously ill particularly contribute to the extensive consequences.

Life and health

The scenario would have a very large impact on Life and Health. It is estimated that 2,500 people would die and 8,000 would become seriously ill if there was no insulin and antibiotics for three weeks. The estimate is based on the fact that there are around 30,000 people in Norway with type 1 diabetes who depend on daily insulin treatments. Approximately 3,000 patients need to pick up new doses of insulin from pharmacies every week. If insulin was in short supply for three weeks, 9,000 patients would therefore be affected. We assume that two thirds of these would purchase insulin immediately after the shortage becomes public knowledge, while one third (3,000 people) would run out of insulin during the three weeks the shortage lasts. More than 90% of these would develop diabetic ketoacidosis and either die or become seriously ill in a very short space of time.

Many patients with type 2 diabetes also rely on insulin. An estimated 20 per cent of these would become seriously ill and require hospital treatment (approximately 7,000 people). A shortage of antibiotics would also result in many fatalities and more serious illness among patients with serious infections.

The scenario would have very large consequences for life and health.

Economy

The scenario would have large economic consequences. It is estimated that the direct costs associated with hospitalisations alone would be around NOK 2.2 billion. The analysis assumes that 8,000 people would become seriously ill and require hospitalisation. It is assumed that the average period of hospitalisation would be seven days at a daily cost of NOK 40,000 (intensive care). In addition to this come the costs associated with extra staffing in hospitals and nursing homes. The indirect economic losses in the form of lost production due to sick leave has been calculated as NOK 200 million. This amount is based on seven days of sick leave for 15,000 people.

The scenario would result in large direct costs and small indirect costs.

Societal stability

The social and psychological response of the public has been assessed as very large. An extensive drug shortage would be an unknown problem for the vast majority of people, occur very unexpectedly and affect vulnerable patients. The drug shortage affects the whole of Europe and would be impossible to escape. The situation would result in doubts and mistrust in relation to the health authorities. The event would cause uncertainty among the population with respect to the authorities' ability to cope, duration of the crisis and the consequences it would have.

The event would cause a very large social and psychological response among the public.

Assessment of uncertainty

The health sector has experience of coping with sporadic shortages of medicines, but there is less experience of extensive shortages of vital drugs. There are a few experts with in-depth knowledge about drug supplies, but elsewhere in the health sector and society drug shortages are a relatively unknown phenomenon.

Small changes in the assumptions in the scenario – particularly with respect to which drugs are involved – would affect the consequences, especially for life and health. Therefor, fatalities and serious injuries and illness are sensitive to changes in the assumptions.

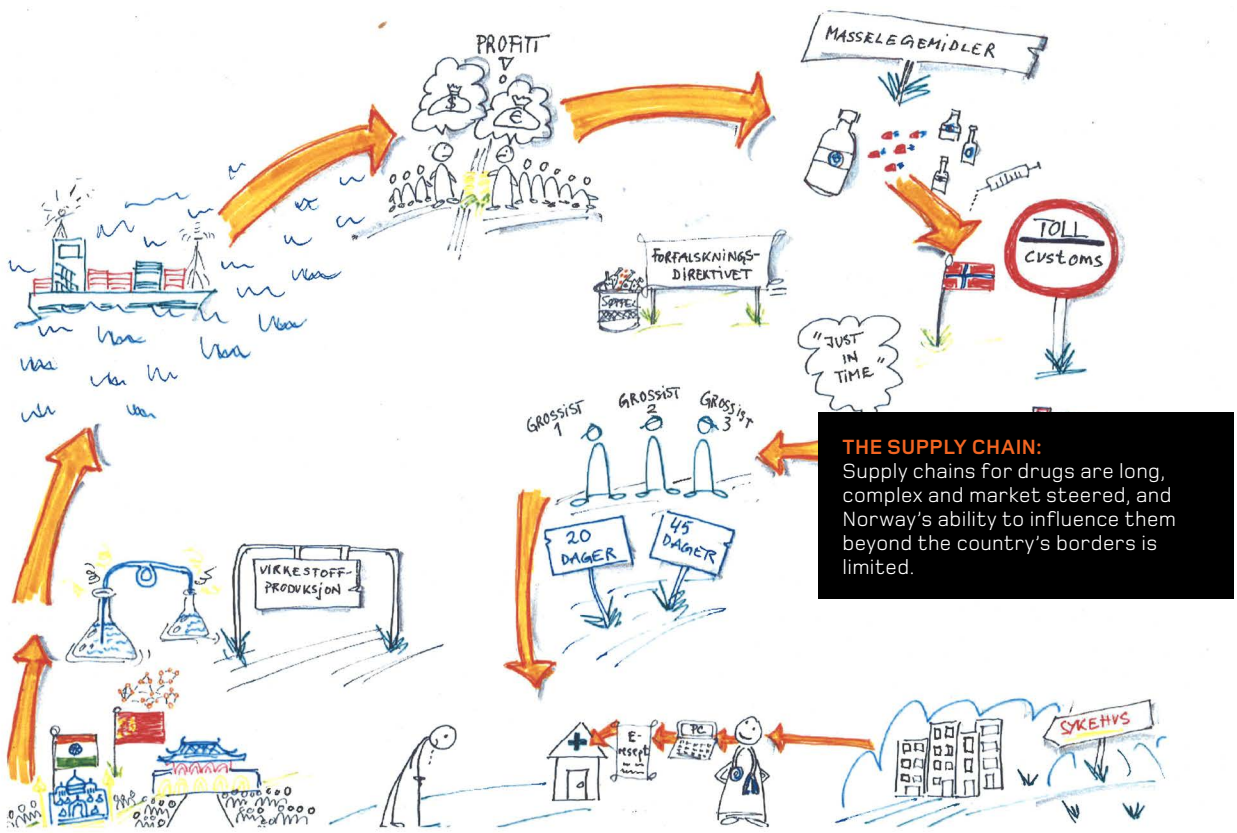
At the same time, shortages of drugs other than those analysed in the scenario could also have serious consequences, even in the case of a shortage lasting just a few weeks.

The uncertainty has been assessed as *medium*.

Possible measures

- Enter into mutually binding agreements between Nordic/European countries ('virtual stocks').
- Stipulate requirements for larger stocks of drugs in more links in the chain (wholesalers, pharmacies and hospitals).
- Establish formal legal authority for the health authorities to introduce partial or full sales stops for pharmacies and wholesalers to avoid the hoarding of drugs.
- Establish formal mechanisms for prioritisation in the event of a shortage.
- Assess solutions for direct notification and information from the health authorities for affected patient groups. ◎

ILLUSTRASJON JANNICHE CRAMER / DSB



THE SUPPLY CHAIN:
Supply chains for drugs are long, complex and market steered, and Norway's ability to influence them beyond the country's borders is limited.

TABLE 25. Schematic presentation of the results from the risk analysis.

Likelihood assessment							Explanation
LIKELIHOOD OF THE EVENT OCCURRING IN THE COURSE OF 100 YEARS		**VERY LOW**	**LOW**	**MODER-ATE**	**HIGH**	**VERY HIGH**	
The specific analysed scenario					◎		75% likelihood of occurring in a 100-year period.
Similar events involving other types of drugs						◎	More than 90% likelihood of occurring in a 100-year period. The consequences might be less serious than those in the analysed scenario.
Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities					◎	An estimated 2,500 fatalities, mainly due to shortages of insulin and antibiotics.
	People affected by serious injuries and illness					◎	An estimated 8,000 people who experience exacerbated conditions.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses				◎		Approximately NOK 2.2 billion due to hospitalisations.
	Indirect economic losses		◎				NOK 200 million in lost production due to sick leave.
Societal stability	Social and psycho-logical response					◎	A shortage of vital medicines would create anxiety, fear and mistrust in the authorities.
	Stress on daily life						Not relevant.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern						Not relevant.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎		Four of the ten consequence types would be affected to a large or very large extent.
Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, uncertainty has been assessed as *medium*.

SEA OF PEOPLE AND FLOWERS: More than 150,000 people gathered in the streets of Oslo to mark their disgust at the terrorists attack on 22 July.

PHOTO KRISTER SØRBØ / VG

15

POLITICALLY MOTIVATED VIOLENCE

Background

The use of violence is described as terrorism when the purpose is of a political or ideological nature. Section 131 of the Norwegian Penal Code defines terrorism as acts committed with the intention of:

a. seriously disrupting a function of vital importance to society,
b. causing serious fear in a population, or
c. wrongfully compelling public authorities or an intergovernmental organisation to perform, submit to or omit to do something of substantial importance to the country or the organisation, or to another country or intergovernmental organisation.

Sometimes the goal is also to create or reinforce conflicts the terrorists' side can exploit. While the consequences of an attack can be highly destructive, the damage or fatalities are not the actual purpose of the terrorist act.

Violence as a political means is not a new phenomenon. Terrorism has been used for a long time by some political authorities to force entire populations, or parts thereof, into submission. Nonetheless, the concept of terrorism has primarily come to be associated with political violence carried out by non-state actors, where the goal is to impact or influence governments and the power system.

Political terrorism as we know it today is closely correlated with the development of new mass media, the printed press in the 1800s and TV in the 1960s. The subsequent growth of the Internet and social media has contributed to this as well.[202] From the terrorists' standpoint, media coverage is important for ensuring that the use of violence has the desired effect. Therefore, the phenomenon can also be understood as an act of communication. The terrorist's foremost desire is attention. This makes the role of the media important.

The boundaries of what can be regarded as politically motivated violence and what can be regarded as hate motivated violence can be fluid. The motives of individual perpetrators of violence may be complex and unclear. It can be difficult to understand some terrorist acts without assuming that hate is also a crucial element of the motivation. At the same time, it has been pointed out that while violence carried out by a person from a minority group against the majority population is often referred to as terrorism, violence against minorities tends to be categorised as being motivated by hate or a result of psychological imbalance.

[202] *Store norske leksikon*

Most of the terrorist attacks in the West in the last decade have been carried out by people affiliated with, or inspired by, jihadist movements. Jihadism is a violent, extreme tendency within Islamism based on armed combat in the form of holy war (jihad) and aimed at bringing in an Islamist form of government locally or a global caliphate. [203/204] The Al-Qaida network and ISIL ('The Islamic State of Iraq and the Levant') are the two most widely known jihadist movements.

Right-wing extremists have also carried out many acts of terrorism in Europe and the USA. The crimes committed in Oslo and on the island of Utøya on 22 July 2011 constituted one of the most serious terrorist attacks in European history during peacetime. The perpetrator detonated a bomb in the government quarter in Oslo and killed eight people. Immediately following this, the same perpetrator shot and killed 69 people on Utøya in the Tyri Fjord, where around 600 young people had gathered for the annual summer camp organised by the youth section of the Norwegian Labour Party. Many more were physically and/or psychologically injured.

Risk

The presentation in this chapter is based on the Norwegian Intelligence Service's (NIS) open assessment of relevant security challenges, 'Focus 2018', and the Norwegian Police Security Service's (PST) open Threat Assessment 2018. It must be stressed that the threat picture within the area of politically motivated violence is constantly changing. The NIS's and the PST's open assessments have a time horizon of one year, which is substantially shorter than the assessments carried out for most other risk areas in ACS. Therefore, users of this document should consult the latest available edition of Focus and the PST's open Threat Assessment.

The NIS points out that ISIL lost its capacity to recruit foreign fighters on a large scale after the organisation was militarily defeated in Syria and Iraq in 2017. However, previous recruitment and mobilisation will have effects for many years into the future, and the terrorist threat against Europe from this environment will therefore continue to exist. Foreign fighters in Syria and Iraq have built up a network and expertise that can be used by new groups. In addition to this, a narrative asserting that ISIL managed to realise the caliphate could continue to inspire people in Europe to commit acts of terrorism, primarily using simple means. In its propaganda, ISIL encourages terrorist attacks against low-security targets and describes how they can be carried out using sharp weapons and vehicles. The NIS also points out that al-Qaida has been impacted by the loss of important leaders and decades of anti-terrorism measures, and therefore today it appears to be more of a loose network of affiliates rather than a centralised organisation. However, the network is taking steps to create a basis for future growth. One important element of their preparations is building local alliances; a project the group will probably prioritise over attacks in the West.[205]

People and groups inspired by extremist Islamic ideology will, according to the PST, constitute the primary terrorist threat to Norway in a short-term perspective. However, the Norwegian environments appear somewhat weaker compared with the period from 2012 to 2015. Nonetheless, the PST's 2018 assessment is that it is possible there will be attempts at terrorist attacks with a background in extreme Islamism. An attack or attempted attack would probably not be very complex, i.e. an attack by one to two people using sharp weapons or firearms, vehicles or simple explosive devices.[206]

The dominant type of terrorist attack in Europe in 2017-2018 was so-called 'inspired attacks', where one or a few people carry out an attack on their own initiative. Attacks directly ordered by a terrorist organisation are very rare. Therefore, inspired attacks also appear to be the most likely type of terrorist attack in Norway as well. In autumn 2018, the Joint Counter-Terrorism Centre assessed the likelihood of a centrally controlled attack in Norway as 'highly unlikely'.

Two thirds of the terrorist attacks in Europe have been committed by the European countries' own nationals. Less than 20% of the perpetrators had a background as a foreign fighter, although the extent of damage is often greater when such experience is involved.[207]

At the start of 2018, the PST's assessment was that it was unlikely that right-wing extremist groups would commit terrorist acts in Norway in the coming year. Organisation building and recruitment remains the primary goal in this environment. The terrorism threat from right-wing extremists is primarily

[203] *Understood here as a global state that encompasses all Muslims.*
[204] *Store norske leksikon.*
[205] *Focus 2018, Norwegian Intelligence Service.*
[206] *Threat Assessment 2018, Norwegian Police Security Service.*
[207] *Focus 2018, Norwegian Intelligence Service.*

regarded as coming from individuals and small groups on the periphery of the most established groups. In Europe, explosives are the preferred method of attack in acts of terrorism committed by right-wing extremists, followed by firearms and knives.[208]

Prevention and emergency preparedness

Preventing radicalisation and violent extremism must be based on a wide range of means. In many areas it is first and foremost the authorities' efforts that are important, but just as important is the fact that we all, individuals and communities, help to maintain shared attitudes and values that reject violence as a political weapon. An inclusive society that values diversity, that has an open and critical social debate in which hate speech is refuted and which protects important shared humanitarian and democratic values generally has a preventive effect against radicalisation.[209]

Report to the Storting (white paper) No. 21 (2012–2013) Terrorism Preparedness, presents an overarching strategy with five main points that range from prevention to management:

- Preventing radicalisation and violent extremism.
- International cooperation on preventing and combating terrorism.
- Averting and uncovering acts of terrorism before they can take place.
- Protecting society and making it well-equipped to withstand acts of terrorism.
- Managing terrorist attacks as best as possible.

Wide-ranging efforts and cooperation between a number of actors are required to counter adverse developments: in municipalities, schools, child welfare services and the police, and by involving local communities and voluntary organisations. Central to this, is the effort to prevent individuals and groups becoming marginalised by being excluded from school and working life.[210]

In 2014, the Government presented a new action plan against radicalisation and violent extremism. The plan succeeded an earlier plan from 2010. The action plan presents 30 measures in five different areas:

- Knowledge and expertise.
- Cooperation and coordination.
- Prevent the growth of extremist groups and help promote reintegration
- Prevent radicalisation and recruitment through the Internet.
- International cooperation.

Responsibility for the measures was assigned to six different departments: the Ministry of Children and Families, the Ministry of Justice and Public Security, the Ministry of Health and Care Services, the Ministry of Education and Research, the Ministry of Culture and Equality, and the Ministry of Foreign Affairs.[211]

The PST plays a key role in both preventing and averting terrorist attacks. The PST's primary mission is to prevent and investigate crimes against national security. A central part of this involves collecting information about people and groups who may constitute a threat, preparing various analyses and threat assessments, investigations and other operational measures, as well as providing advice.[212]

Terrorism is a serious form of crime that the police are tasked with preventing, combating and investigating. An adverse event will generally be handled by the police district in which the incident occurs. The police district can ask for assistance from the police's national emergency preparedness resources. The police can also request assistance from the Norwegian Armed Forces on the basis of the instructions on the Norwegian Armed Forces' assistance to the police.

Managing a major terrorist incident, such as the one carried out in Oslo and on Utøya on 22 July 2011, requires a huge effort from a number of other actors in addition to the police and Norwegian Armed Forces, such as the health service, fire and rescue services, municipalities and the Norwegian Civil Defence.

[208] *Trusselvurdering 2018, Politiets sikkerhetstjeneste.*
[209] *Report to the Storting (white paper) No. 21 (2012-2013) Terrorism Preparedness.*
[210] *Meld. St. 10 (2016-2017) Risiko i et trygt samfunn.*
[211] *Action Plan against Radicalisation and Violent Extremism, Ministry of Justice and Public Security 2014.*
[212] *www.pst.no*

SCENARIO

15.1 Terrorist Attack in a City

Politically motivated violence comes in different forms and formats. In recent years, there have been many individual attacks in Europe that have involved one perpetrator or a small number of perpetrators, and where vehicles or sharp weapons have been used, although there have also been larger individual attacks using explosives and firearms. In 2010, a risk analysis was conducted of a very serious scenario in which groups of terrorists carry out simultaneous attacks against multiple targets in Oslo. The analysis was adjusted in 2018 based on new knowledge.

Course of events

A suicide bomber detonates 10 kg of explosives at the entrance to the Norwegian parliament, the Storting. Three terrorists then open fire using handguns and throw hand grenades. Ten minutes later, four terrorists storm a larger hotel in the city centre, throwing hand grenades and firing with handguns. A total of 300 guests and employees are taken hostage. In the evening, a 5 kg bomb detonates in a rubbish bin in a large shopping centre in the city and two terrorists open fire on members of the public. The terrorists hold parts of the hotel with hostages throughout the night and trigger bomb belts the following morning.

Time	Scope	Similar events
A weekday at the end of September, at the end of working hours. The attack continues until the next morning.	• The attacks strike three different areas containing many people in the capital. • Several mobile attack teams with many terrorists involved.	• The attacks in Paris and Saint Denis in November 2015 in which 139 people were killed. A total of six locations were attacked using automatic rifles, hand grenades and explosives. • Attack on the gas plant in In Amenas, Algeria in 2013, in which 38 employees from a number of countries were killed, including five Norwegians.

Assessment of vulnerability

Even though several security measures have been implemented since the events of 22 July and terrorist acts in other countries in recent years, it is difficult to protect against terrorists whose primarily goal is to kill, regardless of who or where this might be. Norway is an open society in which people have a high degree of trust in each other and the authorities.[213] Openness is an aspect of Norwegian society, but also a vulnerability that can be exploited by terrorists and other criminals.

Assessment of likelihood

The likelihood of intentional acts is not specifically assessed in Analyses of Crisis Scenarios.

The likelihood of a terrorist attack will vary over time, depending on the international situation, Norway's exposure in the conflict picture and any threat actors' capacity and intention to carry out an attack. In 2018, the PST regarded it as "highly unlikely that we will see attacks in Norway directly controlled by a terrorist organisation or attacks involving many perpetrators" this year.[214]

Assessment of consequences

The societal consequences of the given scenario are assessed as *large*. The scenario will primarily threaten the societal assets Life and health, Economy, Societal stability and Democratic values and capacity to govern. This would have an especially significant impact on the consequence type social and psychological response.

Life and health

The event would have serious consequences for Life and Health. Based on the experiences from similar attacks in Europe, up to 150 fatalities and a similar number of seriously injured could be expected due to the attacks.[215] In their aftermath, delayed psychological injuries and trauma can be expected among a number of those directly affected, emergency response personnel, next of kin and random witnesses. 25 per cent of those affected develop such disorders.[216] Based on this, the total number of ill/seriously injured people after the attacks in the scenario was set at 400–500.

The consequences for Life and Health would be large, both with respect to death and serious injuries and illness.

Nature and culture

The Storting building is protected under the Planning and Building Act. The hotel involved in the scenario is on the Oslo Municipality Cultural Heritage Management Office's list of registered cultural heritage sites in Oslo. It is estimated that the damage to the buildings would be limited and mostly repairable.

The overall damage to cultural assets has been assessed as small.

Economy

The direct economic consequences of the act of terrorism are primarily linked to damage to buildings. The damage to the Storting and neighbouring buildings would be limited. The same applies to the shopping centre. The hotel would sustain the greatest damage. Shooting and bomb explosions would cause serious interior damage and smaller fires would occur. The clean-up, repair and reconstruction costs would be large, and the hotel would be closed for between six to nine months. The shopping centre would be closed for a few weeks.

The damage would also result in high lost earnings for the hotel and the shopping centre that would be struck. There would be extraordinary measures linked to management and reconstruction. It is estimated that there would be major costs linked to new security requirements, rules and regulations that would be a permanent cost driver in society.

Based on the lessons learned from 22 July, the direct economic consequences of the terrorist attack analysed here would be in the range of NOK 500 million to NOK 1 billion, and the indirect economic consequences NOK 2–5 billion.

The direct economic consequences have been assessed as medium, while the indirect consequences have been assessed as large.

---

[213] *"Samfunnsspeilet 2/2016", Statistics Norway.*
[214] *Open Threat Assessment 2018, Norwegian Police Security Service.*
[215] *Official Norwegian Report (NOU) 2012:14, Report of the 22 July Commission.*
[216] *Norwegian Centre for Violence and Traumatic Stress Studies.*

Societal stability

A terrorist attack of this magnitude would cause considerable anxiety among the public. The attack would create reactions such as fear, anger and a sense of impotence. The victims in the hotel would be at the mercy of the terrorists' actions and have very little chance of escaping the attack. Many would believe that this is a type of incident for which the authorities should have been prepared and that should also have been avoided. In time there would be criticism in the media and confidence in the police and authorities would drop for a period of time. Good communication between the authorities and those affected, as well as the rest of the public, would be very important, not least to reduce the level of anxiety. The same applies to the follow-up of survivors, the bereaved and next of kin.

The social and psychological response would be very large.

The event would not result in significant stress on daily life in the form of poorer access to critical services and deliveries, apart from the access to public transport in Oslo city centre being reduced for a few days.

The stress on daily life would be small.

Democratic values and capacity to govern

The bomb attack on the Storting targets a democratically elected institution and thus key values in Norwegian society. The event would constitute a significant violation of shared cultural and democratic values, individual rights and personal safety.

The consequences within the category loss of democratic values and national capacity to govern have been assessed as medium.

Assessment of uncertainty

Terrorist attacks are a well-known phenomenon that has been widely researched. The knowledge base is therefore generally good. At the same time, it is inherent in the nature of terrorism that attackers seek to cause as much shock as possible, including by choosing new and unexpected targets and methods. Overall, the uncertainty associated with the knowledge base is regarded as low.

The consequences are highly sensitive to small changes in the assumptions used in the scenario. The type of weapons, size of bomb and targets, as well as the extent to which the explosions cause buildings to collapse and the time of day (number of people present), greatly affect the outcome. This is especially true for the areas Life and Health, Nature and Culture, and Economy. The management and, not least, the authorities' communication with the public would be of major significance for the outcome for the parameter Societal Stability.

Given that the knowledge base has been assessed as good, but that the results are highly sensitive to minor changes in the assumptions, the overall uncertainty has been assessed as *medium*.

Possible measures

Domestic terrorism can be prevented by preventing the emergence of extremist groups and contributing to the reintegration of people who have ended up in such groups. Together with the prevention of radicalisation and recruitment via the Internet, these are key elements of the Government's Action Plan against Radicalisation and Violent Extremism.[217] The measures require active cooperation at several levels, including locally between the police, municipalities and county councils, child welfare service and more.

The action plan's other focus areas are knowledge and expertise, cooperation and coordination, and international cooperation. The national coordination under the direction of the Ministry of Justice and Public Security will be strengthened. The PST plays an important role in prevention as a central advisory body, and is also responsible for ensuring regional and local coordination is embedded in police districts.

The action plans are dynamic and new measures are constantly being added. Status reports are available on regjeringen.no. The police are responsible for dealing with acts of terrorism. The police's emergency response and crisis management capabilities are key anti-terrorism capacities. Protecting buildings, active intelligence gathering and good preparedness measures are other key means.

[217] *Action Plan against Radicalisation and Violent Extremism, Ministry of Justice and Public Security 2014.*

TABLE 26. Schematic presentation of the results from the risk analysis.

Likelihood assessment	Explanation
The likelihood of intentional acts is not specifically assessed in ACS. In 2018, the PST believed that the likelihood of an attack directly controlled by a terrorist organisation or one involving many perpetrators occurring was low.	

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Fatalities				◎		100–150 fatalities.
	People affected by serious injuries and illness				◎		400–500 ill or seriously injured people due to the attack or delayed injuries cause by it.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment		◎				Damage, but mostly repairable, to listed buildings.
Economy	Direct economic losses			◎			NOK 0.5–1 billion (damage to buildings and clean-up).
	Indirect economic losses				◎		NOK 2–5 billion (management, lost earnings, new security measures, etc.).
Societal stability	Social and psychological response					◎	Fear, anxiety, anger, temporary loss of confidence in the authorities and the police.
	Stress on daily life		◎				Some short-term limits on public transport services.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern			◎			Threat to shared cultural and democratic values.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES					◎		The societal consequences have been assessed as large.

Overall assessment of uncertainty

		VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed *medium*.

SANDY HOOK ELEMENTARY SCHOOL: Angel figures in memory of the schoolchildren killed in Sandy Hook Elementary School shooting in 2012.

PHOTO MIKE SEGAR / REUTERS

16

REVENGE MOTIVATED VIOLENCE

Background

Revenge is basically retribution for something one perceives to be an injustice and violation, and thus a means of restoring what one regards as the moral order. Linguistic expressions such as 'vengefulness' and 'a thirst for revenge' point to the fact that revenge is a feeling related to a strong desire for justice, balance, and to 'get your own back'. To some extent, the Norwegian Penal Code acknowledges this human reaction to violations by stipulating 'justifiable anger' as grounds for reducing a penalty.[218] However, in a state governed by the rule of law, it is the public authorities that are meant to intervene in acts that break the law, not victims through vigilantism.

Revenge can be directed at people, institutions, groups of people or society, which one believes is responsible for an injustice against oneself or a group to which one feels connected. As an extreme consequence, a desire for revenge can lead to murder such as a shooting at a school or workplace, honour killings or blood feuds.

The Revenge Motivated Violence risk area covers intentional acts that result in significant harm in terms of the number of fatalities and seriously injured. The boundaries of what is politically motivated, hate motivated and revenge motivated are often fluid and overlap, and the management of such incidents can be relatively similar as far as the police are concerned. Meanwhile, the prevention of such incidents will often depend on the perpetrator's motives for carrying them out.

School shootings, as they are defined in ACS, are one example of revenge motivated violence, and the main focus of discussion in this risk area. Revenge is a common feature of most of the serious shooting incidents that have taken place in schools around the world. This means that other serious incidents in schools fall outside our definition of school shootings. Two examples of these are the attacks on Kronan in Trollhättan, Sweden, and the Army Public School in Peshawar, Pakistan, which can be defined as a racist motivated hate crime[219] and terrorism, respectively.[220]

As a phenomenon, school shootings can therefore be defined as attacks in which the school was the deliberately chosen target and not a random location, and where the perpetrators have a relationship with the school as a current or former pupil. The school represents a community they feel rejected by. Many school shootings end with the perpetrators committing suicide before they are arrested. However, they do not just want to kill themselves, so the suicide is combined with murder and therefore comes under the category of 'murder-suicide'.

---

[218] *Norwegian Penal Code, Section 80(e); Proposition to the Odelsting No. 90, p. 80.*
[219] *Hate crimes are criminal acts committed against people because of their religion, ethnicity, gender identity, functional ability, etc.*
[220] *Four people died as a result of the attack on Kronan in October 2015, including the perpetrator. The perpetrator had no links to the school and the attack was motivated by hate. Almost 150 pupils and teachers were killed by seven terrorists from the group Tehrik-i-Taliban in the attack in Peshawar in December 2014. According to the group's spokesman, the motive for the act of terrorism was revenge for Pakistan's military offensive in North Waziristan in 2014.*

Studies have shown that three out of four school shooters had exhibited suicidal behaviours or attempted suicide before the attack on the school.[221]

Murder and suicide can be regarded as two alternative, violent means of expressing frustration.[222] In the case of murder, the frustration is directed outward through violence, while in the case of suicide, the frustration is directed inward. However, a murder-suicide incident spans this boundary in that the frustration is directed both outwards and inwards at the same time. By killing others at the same time, school shooters want to take revenge on those they hold responsible for a life not worth living.

On 20 April 1999, 12 pupils and a teacher were killed in a school shooting at Columbine High School in Littleton, Colorado, USA, by two 17 and 18 year old pupils at the school. A further 24 people were injured, three of them as they fled the school building. The Columbine massacre became a source of inspiration and a template for subsequent school shootings, including two school shootings in Finland. This was due, not least, to the 'cultural products' the perpetrators made in advance and published in online videos, images and texts in which they describe themselves, their motives and their plans. They told a story both by what they published in advance and what they actually did.

Risk

Revenge motivated violence is a relatively widespread phenomenon in some criminal groups, where acts of violence are usually not reported but instead breed more violence in a spiral of retribution.[223] Revenge motivated violence is not specifically mentioned or defined in the Norwegian Penal Code and, therefore, is not included in the police's criminal statistics or overview of murders. Thus, it is difficult to assess the scope of violence motivated by a desire for revenge.

School shootings are largely regarded as an American phenomenon. 76 school shootings, or 63 per cent of all school shootings on a global basis up to the end of 2011, occurred in the USA. This is almost twice as many as in every other country combined.[224] Of the 44 school shootings that have occurred outside the USA, 20 were in Europe.[225] While the number of school shootings in the USA gradually increased in the 1990s before stabilising, the number of school shootings outside the USA have largely occurred after 1999. The annual rate of school shootings was 1.1 in the 1980s, 3.6 in the 1990s and rose to 5.7 in 2010.[226] According to an independent organisation that monitors the number of school shootings in American schools, there were 65 school shootings in the USA in 2017.[227] To date, there have been no school shootings in Norway, but there have been two incidents in Finland, in 2007 and 2008.

Workplace shootings, or so-called 'going postal' incidents, are a similar phenomenon. The term 'going postal'[228] originates from a number of workplace murders in the United States Postal Service in the mid-1980s. According to a review of 125 mass murders in the USA from 1966 onwards, where four or more people were murdered, 27 per cent occurred in workplaces, while 12.5 per cent occurred in schools. Other locations where mass murders have taken place include religious places of assembly, military bases, shops and restaurants.[229] There have been no mass workplace shootings in Norway.

Prevention and emergency preparedness

Good school and workplace environments are a priority area in all Norwegian schools and kindergartens in order to prevent revenge motivated violence. It is known that persistent bullying at school is often what motivates school shooters' desire for revenge. In recent years, many municipalities and County Governors have included intentional acts such as school shootings in their risk and vulnerability analyses and emergency response plans.

---

[221] *US Secret Service and US Department of education (2004), The final report and findings of the Safe School Initiative, Washington.*
[222] *Henry, A.F. og J.F. Short (1954), Suicide and homicide: Some economic, sociological, and psychological aspects of aggression, Glencoe: The Free Press*
[223] *Johansen, Rune C., 2017. "Mørketallsmenn. En kvalitativ studie av begrunnelser for at unge menn ikke anmelder vold." Master's degree these in psychosocial work. University of Oslo.*
[224] *Böckler, N. et al. (2013), School shootings, New York: Springer.*
[225] *All school shootings intended to kill multiple people are included here, not just those in which lives were actually lost.*
[226] *Böckler, N. et al. (2013), School shootings, New York: Springer.*
[227] *https://everytownresearch.org/gunfire-in-school/*
[228] *https://en.wikipedia.org/wiki/Going_postal*
[229] *https://www.washingtonpost.com/graphics/national/mass-shootings-in-america/. Besøkt 25. mai 2016.*

The police are responsible for dealing with serious intentional acts and taking direct action to neutralise the perpetrator(s) to save lives and limit the scope of harm. The national procedures for cooperation between the emergency services in situations of acute and life-threatening violence (PLIVO) describe how emergency response personnel from the fire service, police and health service can save lives and limit the scope of harm in situations where life-threatening violence is being carried out against multiple people.[230]

SCHOOLS ARE RESPONSIBLE FOR DEALING WITH SCHOOL SHOOTING INCIDENTS UNTIL THE POLICE ARRIVE ON SCENE AND THEREFORE MUST HAVE AN EMERGENCY PREPAREDNESS PLAN FOR THIS.

The Regulations on environmental health care in kindergartens and schools requires enterprises to assess the risks and plan emergency preparedness at the enterprise proportional to the risk picture. In a circular dated 5 May 2015, the Ministry of Health and Care Services clarifies that the risk factors that must be assessed in kindergartens and schools include serious intentional acts.

[230] *The Norwegian Directorate of Health, the National Police Directorate and the Norwegian Directorate for Civil Protection. National procedures for cooperation between the emergency services in situations of acute and life-threatening violence (PLIVO). 2015*

SCENARIO

16.1 School Shooting

We define school shootings as attacks on an educational institution where the perpetrator is or has been a pupil or student. The school or university is a deliberately chosen target, and the motive for the act is a desire for revenge resulting from prolonged bullying and social exclusion. Attacks often end with the perpetrator taking his own life, or being stopped by the police.

The risk analysis was conducted in the autumn of 2015 and is documented in a separate report.[231]

Course of events

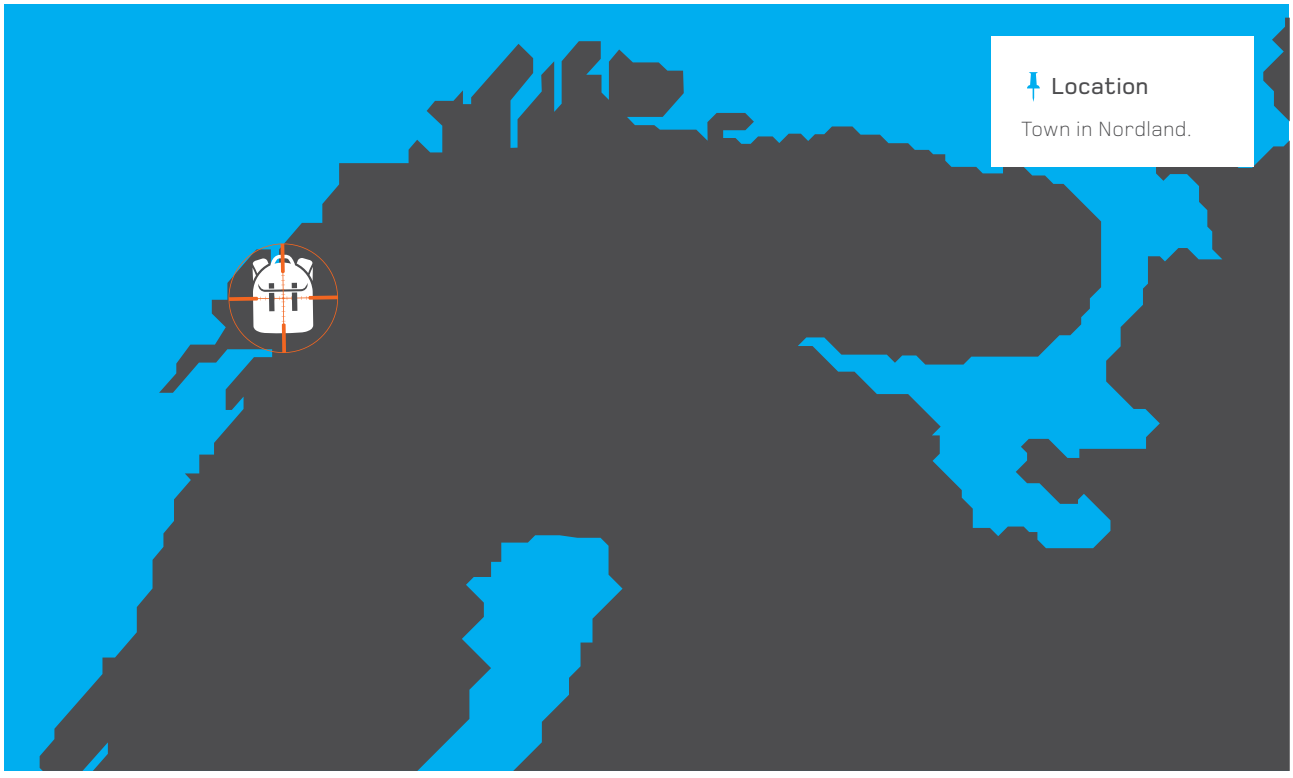
A 17 year old boy walks into the upper secondary school where he is a pupil in a town in Nordland. The night before he had uploaded a video to YouTube in which he describes how intensely he hates the school that has destroyed his life. He says that he feels rejected by pupils and overlooked by teachers. He cannot stand the idea of continuing to live like this, and those whose fault it is deserve to die as well.

On Monday morning, he walks into a classroom and stands inside the doorway. Here, he pulls a handgun and points it at the pupils in the room. He then fires the first shot.

A teacher in another classroom hears the shot and runs to warn the headteacher, who immediately calls the police. The nearest police station is three hours' drive away, but there is a district sheriff's office just nearby where two police officers are normally at work. However, they are on an exercise an hour's drive away when the headteacher reports the shooting.

After an hour, the sheriff's office patrol arrives and at about the same time a helicopter lands carrying personnel from the nearest police station. The perpetrator realises he will be arrested and shoots himself.

Time	Scope	Similar events
Monday morning. The attack lasts an hour.	One school shooter attacks fellow pupils and teachers with a handgun at a school with 150 pupils.	• Jokela School in Tusby, Finland, in 2007. The perpetrator was an 18 year old pupil, who committed suicide. Eight died and 13 were wounded. • Albertville-Realschule in Winnenden, Germany, in 2009. The 17 year old perpetrator was a former pupil at the school. A total of 16 people died in the shooting, including the perpetrator. • Stoneman Douglas High School in Parkland, Florida, USA, in 2018. The 19 year old perpetrator was a former pupil at the school. A total of 17 people died in the shooting.



[231] *DSB (2015). "Nasjonalt risikobilde: Risikoanalyse av skoleskyting i Nordland."*

Assessment of vulnerability

One crucial factor in the outcome of a school shooting is the police's response time from report to arrival on scene. The response time of the police is more important than those of the other emergency services, since normally only the police can operate within firing range and intervene against a perpetrator. Response times outside cities and larger towns can often be long because of the great distances.[232] A school shooter only needs a few minutes to do a great deal of harm. In order to compensate for long response times, schools need a good emergency preparedness plan so they can deal with incidents themselves until the police arrive. Surveys of schools show that many lack risk and vulnerability analyses, emergency response plans and drills for school shootings and similar incidents.[233]

There are indications that the knowledge about school shootings is low and variable among teachers. American studies show that school shooters are often quiet, uncommunicative adolescents that feel severely bullied and lonely.[234] However, two Norwegian master's degree theses show that many teachers believe it is the 'troublemakers' who are most likely to carry out a school shooting.[235] It is important to recognise the behavioural danger signals and be able to implement measures when they are detected.

Assessment of likelihood

The likelihood of intentional acts is not specifically assessed in Analyses of Crisis Scenarios.

The perpetrators of school shootings are often severely downtrodden, frustrated, angry and psychologically unstable. They associate their problems with the school they attend and the motive is a combined desire for revenge, attention and suicide. It is not inconceivable that adolescents in Norway can both have suicidal thoughts and feel an intense hatred of their school. However, there are also preventive barriers to school shootings in Norway, such as systematically working on inclusion and good learning environments in schools. The level of violence among adolescents is low and Norway has strict weapon laws and a strict weapons culture.

In other words, the preconditions for school shootings also exist in Norway.

Assessment of consequences

Overall, the consequences of a school shooting in Norway have been assessed as *medium*. The greatest impact would be in relation to the consequence type Social and psychological response.

Life and health

It is assumed that a total 16 people are killed in the school shooting scenario. 14 pupils and a teacher are shot, and the perpetrator commits suicide. Ten pupils are also wounded in the shooting.

After a school shooting incident, many of those involved would experience post-traumatic reactions. Both those who have experienced life-threatening and frightening situations and those who are witness to others doing so can develop post-traumatic stress disorder. The degree of exposure is a significant factor in the development of post-traumatic stress, i.e. how scared one is and for how long one is scared. The relationship to the perpetrator and physical proximity to the incident are also relevant factors.

It is estimated that, on average, 20–30 per cent of those involved in highly dramatic incidents suffer post-traumatic stress to a greater or lesser degree. In this scenario, 40 people would experience more or less serious post-traumatic stress disorders in the aftermath of the school shootings. Everyone who was in the school and the families of victims and survivors may require psychological first aid and psychosocial follow-up.

Within the ACS methodology, the consequences for life and health have been assessed as small.

Economy

The reconstruction costs for the school after the incident are estimated to amount to NOK 50–100 million.

---

[232] *According to the National Police Directorate's measurements from 2015, the response time for 80% of emergency responses in sparsely populated areas was 33 minutes nationally and 53 minutes in Nordland.*
[233] *NIFU Report 2017:31, Questions for schools in Norway autumn 2017.*
[234] *US Secret Service and US Department of education (2004), The final report and findings of the Safe School Initiative, Washington.*
[235] *Laila Haugbro, (2013), "Hvis ulven kommer i morgen–Læreres syn på, og vurdering av, alvorlige skolehendelser"; Hanne Vik Vo, (2013), «Våg å tenke det verste!», University of Stavanger.*

The direct economic losses have been assessed as very small.

As a result of the incident, security would be tightened at other schools, including through the installation of alarm systems, altering school buildings and so on.

The indirect economic losses have been assessed as very small.

Societal stability

We have seen in other countries that school shootings cause strong reactions such as grief, anger and concern among the public. The fact that the victims are children and young people in school where they should be completely safe would feel very brutal and breach the social contract. It is easy for other pupils, teachers and parents to imagine such an incident affecting them.

The social and psychological response after the incident has been assessed as very large.

Following the incident, alternative school premises would be required for the pupils and the teaching would suffer for a period of time.

The stress on daily life has been assessed as very small.

Democratic values and capacity to govern

A school shooting would be perceived as a violation of personal safety and important shared social values. However, according to the ACS methodology, it would not have a major impact on the consequence type Loss of democratic values and national capacity to govern.

The consequences for democratic values have been assessed as small.

Assessment of uncertainty

School shootings are a known and studied phenomenon, especially in the USA. Previous school shootings have been investigated and researched, and many of the incidents have received a lot of media coverage. However, little research into the phenomenon in a Norwegian context exists. The knowledge base is regarded as good. The scope of the consequences is moderately sensitive to changes in the assumptions used in the scenario. Reducing the police's response time from one hour to ten minutes could have a major impact, but it is not realistic to expect a ten-minute response time at all times. The uncertainty has been assessed as *small*.

Possible measures

Measures for reducing the likelihood of school shootings include ensuring an inclusive and good learning environment for every pupil in school. It is enough for one to feel like an outsider for problems to arise.

How much teachers know about what characterises a potential school shooter is crucial with respect to intervening and providing relevant follow-up.

The measures for mitigating the consequences should a school shooting occur include having good, well-thought through emergency response plan for this type of incident. Decisions must be made about how pupils and teachers should be warned and the equipment and procedures for this should be established and practised. One critical point is to clarify how pupils and teachers should react when a possible school shooting incident occurs (lock, escape, hide, etc.).

Municipalities and County Governors should ensure that school shootings are included as an adverse incident in their overall risk and vulnerability analyses and emergency response plans.

The Ministry of Education and Research, which bears overall responsibility for public safety and emergency preparedness in the education sector, is responsible for monitoring what is being done in schools to prevent and deal with school shootings.

TABLE 27. Schematic presentation of the results from the risk analysis.

Likelihood assessment	Explanation
The likelihood of intentional acts is not specifically assessed in ACS. The preconditions for school shootings also exist in Norway, so such an incident is not inconceivable.	

Consequence assessment

SOCIETAL ASSET	CONSEQUENCE TYPE	VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
Life and health	Fatalities		◎				A total of 16 people die. 14 pupils and a teacher are shot, and the perpetrator commits suicide.
	People affected by serious injuries and illness		◎				Ten pupils are wounded in the shooting and 40 people develop post-traumatic stress disorders. A total of 50 people become ill or are seriously wounded.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses	◎					Estimated reconstruction costs for the school following the incident of NOK 50–100 million.
	Indirect economic losses		◎				Security measures at other schools.
Societal stability	Social and psychological response					◎	A school shooting would cause strong reactions such as grief, anger and concern among the public, and breach the social contract since people expect children to be safe at school.
	Stress on daily life	◎					Teaching in temporary premises for at least one year after the incident due to reconstruction work in the school.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern		◎				A school shooting would be perceived as a violation of personal safety and important shared social values.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES				◎			The social consequences have been assessed as *medium*.

Overall assessment of uncertainty

		VERY SMALL	SMALL	MEDIUM	LARGE	VERY LARGE	
KNOWLEDGE BASE AND SENSITIVITY			◎				The uncertainty has been assessed as *small*.

PHOTO DANIEL C. COXWEST / US NAVY / POLARIS

TRIDENT JUNCTURE 2018:
Warships from multiple nations sailing in formation in the Norwegian Sea.

17

AGGRESSION BY FOREIGN STATE

Background

The Norwegian Armed Forces' long-term plan describes the general conditions for Norwegian security as having worsened in recent years. The security policy situation in our part of the world has not been as demanding for a long time. Major challenges close to NATO's area of responsibility can have direct consequences for Norwegian and Allied security. Globally, states with growing economies are challenging the position of Western countries in international politics. This is contributing to a global, as well as a regional, power shift. Some emerging major powers have authoritarian forms of government, market economies and stronger military capabilities.

Economic and political developments are creating space for superpower rivalry. Breaches of international law, and disagreements concerning goals and means in international cooperation on achieving peace and stability, are undermining international security. These global developments will probably characterise the world for a long time to come and will also affect Norwegian areas and interests. Our part of the world is also changing. The combination of demanding internal and external developments is placing pressure on politics, the economy, solidarity and the ability to meet fundamental challenges with good, effective means.[236]

Technological advances have opened up new opportunities for the use of force in the international arena. Intelligence gathering, sabotage, disinformation and manipulation that before would have required a greater degree of physical presence, can now be carried out via the Internet. It can be difficult to detect such activities and, if they are detected, it can be difficult to attribute them to a specific actor with a high degree of certainty. The uncertainty and ambiguity associated with who is behind the activities, and whether there are any links between different incidents, help to make such attacks difficult to manage, especially for Western democracies with their high degree of openness and freedom to form one's own opinions.

The Norwegian Institute of International Affairs (NUPI) describes *hybrid warfare* as follows:

"A conflict [...] can also be fought and decided on a political and diplomatic level, in the information sphere and within the economy and finance, culture and cyberspace. An actor will often coordinate various activities in order to achieve the maximum – and hopefully strategic – effect. The greater the effect an actor can achieve by combining non-military activities, the less need there will be to use expensive military means.

However, military force and the ability to escalate a conflict to a military confrontation will remain an important element. It helps to underpin the non-military activities.

[236] *Proposition 151 S (2015–2016) Combat Force and Sustainability.*

Military exercises are a typical means of reminding an adversary that the threat to use military force is genuine. [...]

In hybrid warfare it is [...] opinion and politicians who are the main targets – an actor wants to influence these. In other words, the fight is about cognition – about how the conflict should be understood. This often requires means other than purely physical ones. The goal is often to wear down the will to resist the actions an actor wants to force upon an adversary."[237]

The threat actor will seek to put pressure on its adversary using the tools at its disposal. These can be more or less open economic and diplomatic means, or take the form of cyber operations where it is difficult to prove who is behind them. The actor will seek to place the authorities in a hard to manage situation by creating or reinforcing problems, while at the same time underpinning local unrest and internal differences through information operations in order, among other things, to sow distrust in the Government.

Using a combination of different means of power to achieve political benefits in the international arena is not a new phenomenon. It is the managed, more systematically complex and covert use of them that is new and which are associated with the term 'hybrid warfare'. In the past, it was common to distinguish between conventional and unconventional warfare, where the latter has often been used by the weaker party in asymmetrical conflicts, that is, in disputes where there are major disparities between the actors with respect to the resources at their disposal. In recent years, developments have meant that the distinction between conventional and unconventional military force is being erased, and that the distinction between war and peace has become less clear.

In 2017, the DSB conducted a risk analysis of a hybrid attack on Norway, which is documented in a classified report.

Risk

The presentation in this chapter is generally based on the Norwegian Armed Forces' long-term plan and on the Norwegian Intelligence Service's assessment of current security challenges, Focus 2018.

What is meant by hybrid warfare?

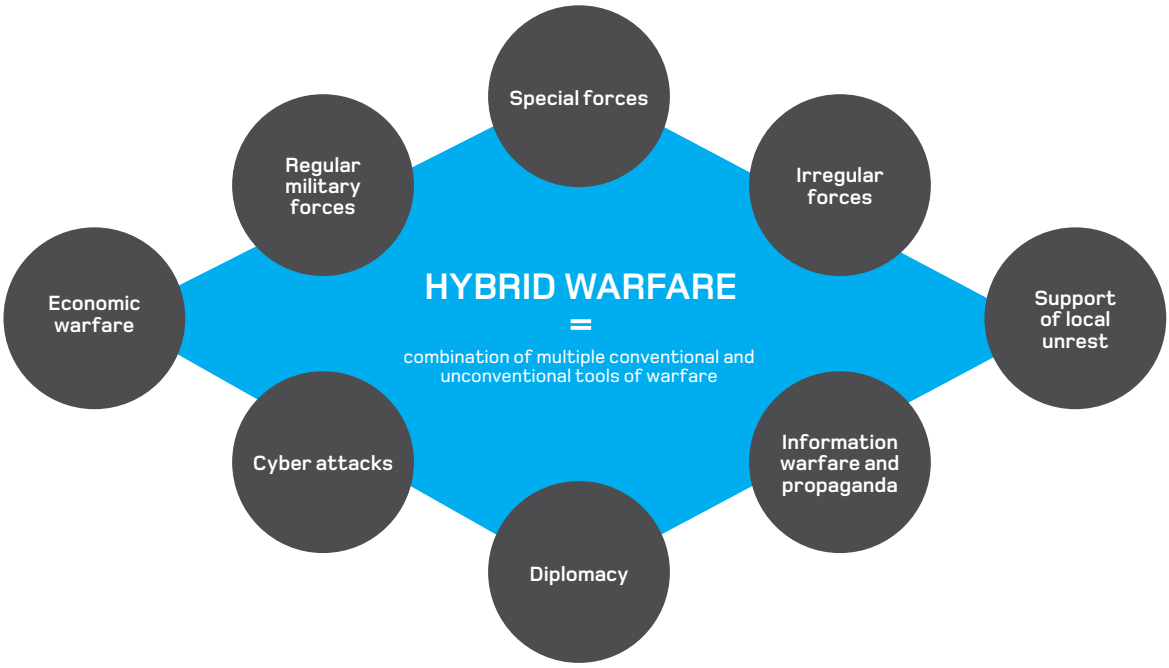


FIGURE 10. Source: MSC, www.securityconference.de

[237] *NUPI 2016, "Hvor hender det? Hybrid krigføring - hva er det?"*

Norway is in an important strategic location in Northern Europe, and has large sea areas with substantial fish and petroleum resources. The Government considers the northern regions to be Norway's most important strategic area of responsibility, and Norway has the right and obligation to secure its own sovereignty and rights.[238] The northern regions are also important to Russia from a geopolitical and strategic military perspective. The bases for its sea and air based nuclear armed forces, and sea and land based missiles, are located on the Kola Peninsula, not far from its border with Norway.[239] Norway's relationships with Russia and the former Soviet Union have largely defined Norway's security policy orientation since 1948.

Tensions in the northern regions have generally been low, and Norway's relationship with Russia has for a long time largely be characterised by stability and cooperation. Nevertheless, Russia's military development is increasing the asymmetry in the relationship between the countries. The combination of Russian military development and more unpredictable political behaviour means that Russia remains a key factor in Norwegian defence planning.[240]

In recent years, Russia has strengthened it military capabilities and exhibited an increased willingness to use military force. Its ambition is to re-establish the country as a superpower. With the war in Georgia in 2008, the illegal annexation of Crimea in the spring of 2014 and the destabilisation of Eastern Ukraine, the Russian government has demonstrated a willingness and ability to use a wide range of means, including military force, to sustain political dominance and influence.

Russian security strategies and military doctrines indicate that the Russian authorities want to exert influence in their immediate vicinity. This particularly involves preventing the further expansion of NATO eastwards and the establishment of bases and deployment of military equipment in these areas. Russian leaders have expressed their lack of trust in the intentions of Western countries, especially with respect to NATO's role in the Baltics and Eastern Europe.[241]

Russia does not regard Norway as being part of its own sphere of interest, and the Norwegian authorities do not regard Russian military activities in the immediate vicinity of Norway as being directed against Norway. Therefore, Russia does not constitute a military threat to Norway today. The Russian activities in the north are primarily aimed at strategic deterrence, as well as ensuring access to the North Atlantic for the country's capacities on the Kola Peninsula. However, the key role these sea areas play in Russia's bastion defence concept entails the possibility of Russia seeking to refuse or control access to sea and land areas that also include Norwegian territory. There may be an attempt to activate the concept in a situation of heightened military tensions between Russia and NATO in Europe, or for that matter in a situation where neither NATO nor Norway are a direct party to a conflict with Russia.[242] It is impossible to rule out the fact that Norway may be drawn into a conflict because of its proximity to Russia's strategic nuclear weapons. Norway could also become involved in a security policy conflict due to our obligations to other NATO allies.[243]

Actors other than Russia also use hybrid means. This includes state as well as non-state actors. Iran's activities in places such as Iraq and Syria bear such characteristics, and irregular groups such as ISIL and Hezbollah also use such means.[244] In a conflict situation, NATO would also look at combining military and non-military means.

The increased opportunities that technological advances provide to carry out operations against a state without a physical presence in the immediate vicinity, means that it is conceivable that Norway could also be subjected to political pressure from more distant actors, both state and non-state actors. Even though military means of force will not form as large a part of the threat picture, dealing with such a situation could still be demanding – also because one could not say with a high degree of certainty who is behind it.

China is increasingly behaving like a traditional superpower with a greater willingness to use force to advance its interests. It is also exhibiting a greater willingness and ability to assume a global leadership role. As a superpower, China is prioritising naval strength with a navy that is in the process of achieving a global range with a presence in all sea areas, including near Norway. At the same time as China is presenting itself as a positive contributor to global governance, it is exhibiting a greater willingness to promote its own interests.

---

[238] *Prop. 151 S (2015–2016) Combat Force and Sustainability.*
[239] *Chief of Defence's Strategic Defence Review, 2015*
[240] *Prop. 151 S (2015–2016) Combat Force and Sustainability.*
[241] *Ibid.*
[242] *Ibid.*
[243] *Forsvarssjefens fagmilitære råd, 2015.*
[244] *Countering hybrid warfare, MCDC 2017.*

This is happening despite its activities causing increased friction, especially in its immediate vicinity. China is using a wide range of means against other actors in East Asia, and has successfully integrated different types of means to maximise its influence. One example of this relates to South Korea's decision to deploy an American missile defence system in 2016. The country became the target of an apparently coordinated Chinese campaign, which included network operations, economic sanctions and propaganda.[245]

The NIS points out that China's ambitious objectives of becoming a global leader with respect to both international strength and international influence, will contribute to increased tensions, especially in relation to the USA.

Prevention and emergency preparedness

The main goal of Norwegian security and defence policy is to protect Norway's sovereignty, territorial integrity and political freedom of action. The mainstay of Norwegian security policy is the NATO alliance and the transatlantic security community.[246]

National defence is one of the state's most important tasks, and in Proposition 151 S (2015–2016) Combat Force and Sustainability, the Government indicates that the capacity to deal with crises and armed conflicts in the immediate vicinities of Norway and its allies must be afforded greater priority. It is especially important to strengthen preparedness and Norway's capacity to deal with the most extensive tasks: defending against threats, strikes and attacks.

THE MODERNISED TOTAL DEFENCE CONCEPT ENCOMPASSES MUTUAL SUPPORT AND COOPERATION BETWEEN THE NORWEGIAN ARMED FORCES AND CIVIL SOCIETY [...] ACROSS THE ENTIRE CRISIS SPECTRUM – FROM PEACE VIA SECURITY POLICY CRISIS TO ARMED CONFLICT.[247]

Norwegian security and defence policy must increasingly assume that changes to our security policy surroundings can occur very quickly. There is also a need to build up expertise and preparedness aimed at strengthening Norway's capacity to deal with hybrid threats.

The core principle in the traditional total defence concept was that it should be possible, if necessary, to mobilise the country's total resources in order to defend the country and to deal with acute and precarious security challenges during an armed conflict or when an armed conflict threatens.

In a serious crisis situation or an armed conflict, the Norwegian Armed Forces' need for civilian support in the form of services, goods, personnel and access to infrastructure would exceed its normal resources. Key resources the Norwegian Armed Forces would need include road, rail, maritime and air transport (and the associated infrastructure) for moving personnel, materiel and supplies, as well as for evacuation. Access to civilian health personnel and services, as well as more specialised services such as maintenance and engineering services, would also be essential. There will be a need for supplies of a number of goods, where fuel supplies to support transport services and the Norwegian Armed Forces' operations would be among the most important. Both civilian suppliers that provide support to the Norwegian Armed Forces and the Norwegian Armed Forces themselves, to some extent, also depend on basic services such as power supplies and, increasingly, civilian ICT infrastructure and services. Shorter readiness preparation times for military units also mean that the support must be able to be deployed faster.[248]

[245] *FOCUS 2018. The Norwegian Intelligence Service's assessment of current security challenges.*
[246] *Prop. 151 S (2015–2016) Combat Force and Sustainability.*
[247] *Support and Cooperation. A description of the total defence in Norway (Ministry of Defence and Ministry of Justice and Public Security 2018).*
[248] *Prop. 151 S (2015–2016) Combat Force and Sustainability.*

NORDRHEIN-WESTFALEN, GERMANY:
Deutsche Telekom's Cyber Defence Centre in Nordrhein-Westfalen, Germany.

PHOTO HENNING KAISER / DPA

18

CYBER ATTACK

Background

Norway is one of the most digitalised countries in the world.[249] However, this development is creating vulnerabilities. A steadily increasing number of devices, processes and services are linked together and to the Internet. This entail digital value chains that are long, complicated, complex and often international, and to some extent beyond the control of the Norwegian authorities. The total digital surface that could be attacked is growing. Elements that are basically well protected are becoming exposed to vulnerabilities via other poorly protected elements in the same value chain.[250]

The fluidity in the digital market, where suppliers are switched, companies bought up, new technology launched and the old is rapidly replaced by the new, contributes to further complicate the picture. The complexity in the interdependencies between the services people see, and the underlying infrastructure on which the services are based, will only continue to grow. The consequences of such structural vulnerability are to some extent difficult to grasp and unpredictable. An increasing degree of interconnection means that the risk of individual incidents having ripple effects is increasing.[251]

The Cyber Attack[252] risk area covers intentional acts that cause society substantial losses by exploiting vulnerabilities in digital infrastructure and digital value chains. Most cyber attacks will be network-based, i.e. they will exploit the opportunities presented by computer systems being interconnected in a global network. Such acts are often politically or financially motivated. Cyber attacks can be difficult to detect and difficult to attribute to a particular actor with a high degree of certainty ('the attribution problem', see also chapter 17). Meanwhile, vulnerabilities can also provide a starting point for more randomly triggered incidents, e.g. due to human error, system error, natural events and accidents. Our presentation concentrates on serious attacks targeted at the deliverability of critical societal functions.

Cyber attacks of various kinds and varying degrees of severity occur constantly, and represent a major challenge for society and many enterprises. Both state and non-state actors can be responsible for the attacks. Attacks can pose a threat to public safety in general and to national security in particular, especially if critical societal functions are knocked out. NATO has established that cyber attacks can have just as much impact as conventional attacks. Cyber attacks are therefore covered by the NATO Treaty's article 5 on collective defence.[253]

[249] *Comprehensive ICT Risk-Assessment 2017. The Norwegian National Security Authority.*
[250] *Risks 2018. The Norwegian National Security Authority.*
[251] *Comprehensive ICT Risk Assessment 2017, The Norwegian National Security Authority.*
[252] *The The Norwegian National Security Authority uses the term ICT attack (cyber attack). In the National Risk Analysis 2014 the risk area was called 'Cyberspace'.*
[253] *Proposition 151 S (2015–2016) Combat Force and Sustainability.*

Risk

Politically motivated attacks may be motivated by conflict situations in which Norway is involved. These may be at a 'state versus state' level, but there may also be foreign interest groups of various kinds who wish to influence Norwegian politics.

As described under the Aggression by foreign state risk area, we must assume that cyber attacks of various kinds will be one of the means that a foreign state might use against Norway in a heightened security policy crisis. Attacks may be intended to put pressure on the Norwegian authorities and/or weaken defensive capabilities.

A number of states run targeted network-based intelligence operations against Norway.[254] The activities are primarily directed at traditional political and military targets such as the foreign service and the Norwegian Armed Forces. Other targets include other parts of the central government administration, academic institutions, power companies and industrial companies. The Norwegian Intelligence Service (NIS) believes that long-term foreign interest in energy companies and industrial management systems indicate that they have ambitions of being able to sabotage power infrastructure.[255]

There have been several examples of network-based sabotage in Ukraine. In 2016, an IT system for railway traffic management was destroyed and a large transformer station north of Kiev was closed down. Common to both of these incidents was the fact that the actors had infiltrated the computer networks six months or more in advance, and obtained full network administrator rights. According to the NIS, being compromised on this level indicates that far more targets could be knocked out, resulting in longer lasting, complex damage. Therefore, the primary goal must have been to acquire experience and knowledge about sabotage operations to ensure that in time such operations could be carried out against the power supply or could disrupt people, supplies and military forces.[256]

Financially motivated attacks account for a substantial proportion of the current threat picture. According to the Global Threat Intelligence Report, the financial services sector suffered the most attacks on a global basis in 2017.[257] Attacks on banks and other financial undertakings are often attempts at fraud. At the same time, the sector – and society – are completely dependent on business and the public trusting the security of financial institutions' systems. The Financial Supervisory Authority of Norway did not observe incidents that were severe enough to threaten financial stability in 2017. Nevertheless, there were many incidents that were serious, both in terms of scope and duration, linked to payment systems. Several of the incidents resulted in payment orders not being competed in the relevant period. In some of the incidents, payment services were unavailable to more than 30% of the bank customers for up to 24 hours.[258]

Ransom money and encryption viruses were the most widespread malicious software in our part of the world in 2017, and the sort that increased most on a global basis.[259] Even though such attacks are primarily aimed at financial gain, they could have significant societal effects should they strike enterprises and sectors with responsibility for critical functions. The so-called WannaCry attack in May 2017, was one of the most serious attacks the world has seen of this kind to date. The worm, which spread unchecked between computers, exploited a vulnerability in Microsoft's file sharing protocol and the attack resulted in information held in the systems of a large number of enterprises being encrypted, and the enterprises thus losing access to it.[260] The attackers demanded ransom money to decrypt the files. Several hospitals in the United Kingdom were struck and had to stop admitting patients. Two months before the attack, Microsoft distributed a patch that closed the hole the attackers exploited, but far from everybody had upgraded their systems in time to prevent being hit by the attack. The effects of this attack were limited in Norway.

The WannaCry attack in May 2017 were probably triggered by an email, but thereafter spread unchecked between computers and systems within an enterprise and to other enterprises.[261] According to the Norwegian National Security Authority (NSM), email is the dominant cyber attack method. In most of the cases dealt with by NSM NorCert in 2016-2017, the attacker sent emails that were deliberately designed to trick the recipient. The contents often appear relevant and legitimate. The email contains an infected file attachment, or it may contain a link that leads the recipient to a so-called 'watering hole', which is a website that delivers malicious software to designated targets.[262]

[254] *Comprehensive ICT Risk-Assessment 2017, The Norwegian National Security Authority.*
[255] *Focus 2018, The Norwegian Intelligence Service.*
[256] *Ibid.*
[257] *NTT Security 2018.*
[258] *Risk and Vulnerability Analysis 2017, Financial Supervisory Authority of Norway.*
[259] *Global Threat Intelligence Report, NTT Security 2018.*
[260] *Comprehensive ICT Risk Assessment 2017.*
[261] *www.msb.se*
[262] *Comprehensive ICT Risk-Assessment 2017, The Norwegian National Security Authority.*

In January 2018, the computer systems of the South-Eastern Norway Regional Health Authority were hit by an extensive and serious cyber attack. The case illustrates how complicated and complex the current threat picture is, and how vulnerable national infrastructure can be to attack.[263] The attacker was an advanced, professional actor.[264]

The Norwegian National Security Authority (NSM) also points out that enterprises do not always make use of advances within technical security and that inadequate technical systems maintenance, e.g. uninstalled security patches, create unnecessary vulnerabilities. In the case of systems that are disconnected from the outside world and that cannot be reached via network-based operations, the use of insiders will be the most effective attack method.[265]

Prevention and emergency preparedness

Enterprises must survey and secure the physical infrastructure they depend on in order to perform their functions. Protection can also be introduced by establishing redundant solutions, as well as physical measures linked to critical components.[266] System separation is another important risk mitigation measure. This involves ensuring one has the most impermeable barrier possible between systems that are used to manage machines, and systems that are used for communication with the outside world.

The typical pattern for attack in cyberspace involves, as mentioned, an enterprise receiving an email containing infected malicious software. Even if one successfully establishes a good security culture and filtering mechanisms for receiving email, an attacker could, sooner or later, get inside the ICT systems. Since 2014, the NSM has recommended four important measures for preventing malicious software gaining a foothold or spreading:

1. Upgrade software and hardware.
2. Install security patches as soon as possible.
3. Do not assign administrator rights to end users.
4. Prevent unauthorised software running.[267]

The NSM has resources that can help prevent and deal with network operations in the public and private sector. A special framework for ICT security incidents has been established that governs the cooperation between affected enterprises, sectoral response environments and NSM NorCert when an incident occurs and when preparing for them.[268] The framework was primarily created for peacetime incidents, but can be transferred to situations where the national emergency preparedness system applies.

The Joint Cyber Coordination Centre (FCKS) is headed by the NSM and also has members from the Norwegian Intelligence Service (NIS), the Norwegian Police Security Service (PST) and the National Criminal Investigation Service (NCIS). Among other things, the centre contributes with overarching analyses of the incident context.

Cyber attacks against critical societal functions can have consequences for large parts of society. This is especially true if the power supply or electronic communications are hit.

THE MANAGEMENT OF SUCH INCIDENTS WILL THEREFORE INVOLVE FAR MORE THAN THOSE WHO ARE RESPONSIBLE FOR DEALING WITH THE ACTUAL ATTACK, INCLUDING LOCAL, REGIONAL AND NATIONAL COORDINATING AUTHORITIES.

[263] *Focus 2018, The Norwegian Intelligence Service.*
[264] *www.helse-sorost.no*
[265] *Comprehensive ICT Risk-Assessment 2017, The Norwegian National Security Authority.*
[266] *Ibid.*
[267] *The Norwegian National Security Authority's basic principles for ICT security, 2017.*
[268] *Framework for handling ICT security incidents, The Norwegian National Security Authority, 2017.*

SCENARIO

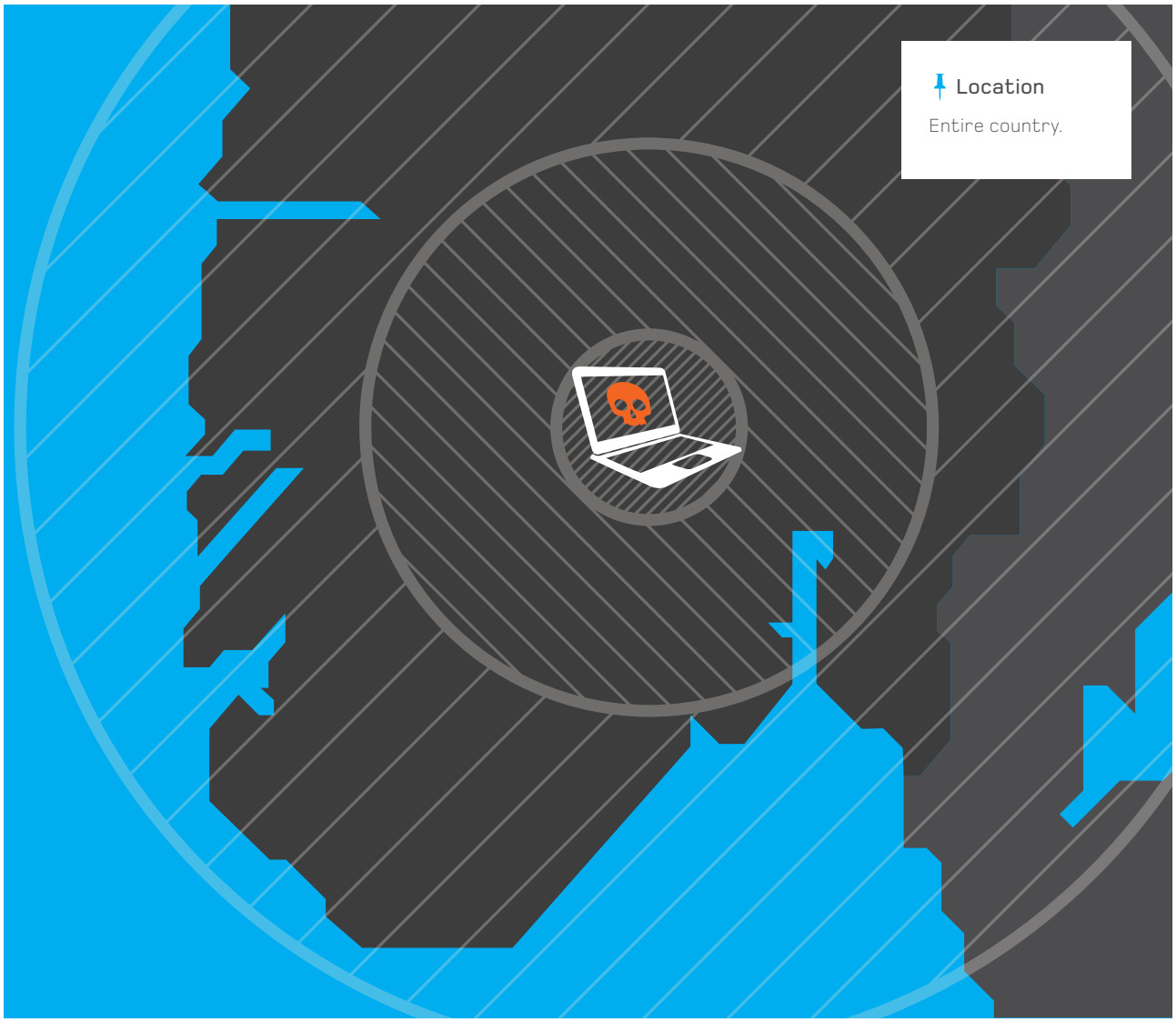
18.1 Cyber Attack on Financial Infrastructure

Financial services are a critical societal function of great importance for business and the public. In the last few decades, the sector has undergone major changes in which the introduction of digital solutions has been central. In 2010, a risk analysis was conducted of a cyber attack on payment systems. The analysis was updated in 2018.

Course of events

An extensive cyber attack shuts down all payment terminals and ATMs in the country. At the same time, a coordinated, massive denial of service attack on Norwegian online banks takes place. This makes the use of payment cards in shops or ATMs impossible. Online banking services are also unavailable.

Time	Scope	Similar events
Occurs on a Friday evening and lasts for a week.	The attack is complex and coordinated. Various methods are used, both network-based and insiders ('disloyal servants').	• No known examples of attacks of this order of magnitude. • Many known examples of smaller attacks on financial services infrastructure. • Many examples of minor outages of payment systems due to logical errors and power outages.



Assessment of vulnerability

The prevalence of digital means of payment means that society is vulnerable to failures in electronic payment systems. Cash is the only realistic alternative. In Norway, the amount of cash in circulation represents less than 2% of GDP. Together with Sweden, we are the country that uses electronic means of payment the most in the world.[269]

Distributing a large amount of cash to the public and business sector would be challenging, partly because there are far fewer physical bank branches than before.

In addition to all types of commercial activity, the transport sector would be affected, partly by people being unable to buy fuel without cash and partly by it being difficult to pay fares on public transport.

The financial system is based on trust. If any doubts arise about whether deposits, securities, etc. are safe, this could cause the stability of the system to deteriorate, which could have serious consequences for the money and capital markets as well, and thereby affect the framework conditions for business in general.

Assessment of likelihood

The likelihood of this type of incident is not assessed in ACS.

The attack is of such complexity which means an actor with a large amount of resources must be responsible. The attacker is a state or another foreign actor with considerable resources. The incident described could be part of a larger attack in which other means are also used. The likelihood of the incident occurring will vary according to the development of the international threat picture and depend on the development of the capabilities of possible threat actors.

The Norwegian Police Security Service states in the National Threat Assessment 2018 that "enterprises within the Norwegian defence and public security sector, public administration, research and development and critical infrastructure are assessed to be particularly at risk of becoming intelligence targets." This applies with respect to both network operations and more traditional intelligence gathering. Several countries' intelligence services have interests within these areas. In Focus 2018, the Norwegian Intelligence Service points out that state actors are building up the capacity to sabotage civilian and military targets in other states. Civilian targets can be systems of critical importance in a modern, industrialised society, such as control and administration systems for power, telecommunications, transport and financial services.

The financial services industry manages substantial assets and attempts at network-based fraud are frequent. Therefore, many actors may have a motive for carrying out extensive attacks against financial services infrastructure, albeit most likely with a slightly different orientation than that which is analysed here.

Assessment of consequences

The societal consequences of the scenario are assessed as *moderate*. The incident would primarily impact economy, societal stability and national capacity to govern.

Economy

The direct economic consequences of the attack would be linked to damage to equipment and software, as well as the cost of implementing cash distribution. It is estimated that in total these would be NOK 100–500 million.

Society's financial 'circulatory system' would be affected. It would probably take several days before means of payment in the form of cash would reach a significant proportion of bank customers. It is estimated that the indirect economic losses due to the incident would be in the range of NOK 2–10 billion. This includes the consequences of irrational financial transactions due to some customers losing confidence in the idea that their deposits are safe, losses due to a reduction in national earnings, and indirect losses, partly due to reduced production outside commercial activities as well.

The direct economic consequences of the attack would be small, but the indirect economic consequences have been assessed as large.

Societal stability

It is expected that the scenario would result in considerable anxiety among the public, partly because of the fear that bank deposits would be lost. The uncertainty associated with the duration of the incident would contribute to insecurity, a feeling of impotence and frustration. The fact that the incident is intentional, would reinforce this and also result in a fear of escalation and further development.

[269] *Bank for International Settlements (BIS), Quarterly Review, March 2018.*

The situation would be experienced as especially frustrating for people unable to take part in the hunt for cash, due to illness or other impairments. Although pharmacies would very likely dispense vital drugs on credit, the worry people would feel about whether or not they will get what they need would be significant.

The social and psychological consequences have been assessed as very large.

The incident would cause significant stress on daily life for the public and many would have to organise their lives differently than normal. Those who do not have cash or are not able to use credit would be unable to access necessities such as food and fuel. Banks would see long queues of customers wanting to withdraw cash, some of them part or all of their balance.

The consequences in terms of stress on daily life have been assessed as large.

The authorities ability to manage the challenges as they arise, come up with effective, extraordinary measures and communicate with the public, would have a major impact on the consequences. Herein also lies the greatest source of the uncertainty associated with the assessments.

Democratic values and capacity to govern

Managing the incident would place a great burden on the authorities and financial institutions. Financial services would largely be knocked out. A lack of access to electronic payment solutions would also be perceived as a violation of individual rights and personal safety and security.

Overall, the effect on the consequence type Loss of democratic values and capacity to govern have been assessed as moderate.

Assessment of uncertainty

The assessments of consequence are based on information from analytical environments and security authorities with extensive access to data and experience from incidents. However, no attack of the scope described here has occurred so far, and this necessarily means there is some uncertainty associated with the assessments. The fact that threat actors will often try to be unpredictable has the same effect. There were no major disagreements among the experts in the analysis seminar.

The results are sensitive to changes in the incident's duration and depend on the ability of the authorities and financial institutions to deal with it. The banks' ability to distribute cash to the public and commercial actors will be of particular significance. It is assumed here that this distribution would take time and therefore not have a significant impact during the week the incident lasts. A faster response could significantly reduce the negative social consequences. The sensitivity of the results has, therefore, been assessed as high. Overall, the uncertainty has been assessed as *medium*.

Possible measures

After the analysis was conducted, the Ministry of Finance amended the regulations to ensure that banks must have solutions in place that can meet any increased demand for cash, should the electronic payment systems fail.[270] The requirements entail a clarification of the obligations concerning cash in the Financial Institutions Act and must be complied with by 1 January 2019.

Local, regional and national exercises can be based on failures in electronic payment systems. It is especially important to gain insight into the kind of management problems an incident such as this could cause for the authorities and commercial actors. ◎

[270] *Regulation on amending Regulations of 9 December 2016 No. 1502 on Financial Institutions and Financial Groups.*

TABLE 28. Schematic presentation of the results from the risk analysis.

Likelihood assessment	Explanation
The likelihood of intentional acts is not specifically assessed in ACS.	

Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities						Not relevant.
	People affected by serious injuries and illness						Not relevant.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses		◎				Damage to software and hardware. Costs associated with the extraordinary distribution of cash NOK 100-500 million.
	Indirect economic losses				◎		Loss of earnings, etc. NOK 2-10 billion.
Societal stability	Social and psychological response					◎	High degree of predictability, very large scope, reactions such as fear, frustration and mistrust.
	Stress on daily life				◎		Electronic means of payment disabled, disruptions/failure of critical services and deliveries, and queues to withdraw cash.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern			◎			Results in governance systems being heavily burdened by crisis management. Significantly weakens the functionality of the financial services sector. Violates individual rights and personal safety and security.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES				◎			Moderate consequences overall.

Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed as *medium*.

SCENARIO

18.2 Cyber attack on electronic communications infrastructure

All critical societal functions depend, to a greater or lesser degree, on electronic communications. Electronic communications infrastructure will therefore be a target of interest for an actor intending to weaken Norwegian society's functioning. The scenario is a cyber attack on Telenor's transport network for electronic communications. The analysis, which was documented in a separate report,[271] was originally conducted in 2014 and updated in 2018.

Course of events		
A logical attack against central nodes in Telenor's transport network destroys both physical components and important software. All commercial electronic communications are paralysed. This also applies to radio and television broadcasts (except satellite broadcasts from abroad). The failure impacts enterprises in many different sectors. A state actor with substantial resources, both with respect to intelligence gathering and network-based sabotage activities, is behind the attack.		
Time	**Scope**	**Similar events**
The attacks occurs on a Monday in September. All electronic communications services are out for five days. Thereafter follows a period of instability that lasts a month.	The attack hits important nodes in several locations in the country simultaneously.	• Attack on the power supply and railway traffic control system in Ukraine in 2016. • Attack on the South-Eastern Norway Regional Health Authority in 2018.

[271] *DSB (2014). National Risk Analysis: Scenario "Cyber Attack on Electronic Communications Infrastructure" – Critical consequential events and consequences in the population.*

Assessment of vulnerability

Telenor's transport network for electronic communications is the only nationwide one in Norway. Broadnet has a transport network that covers 90 Norwegian towns and cities. However, some of the infrastructure is shared with Telenor, and a failure in Telenor's network would therefore also knock out Broadnet's network. Other electronic communications operators such as Telia, Ice, the emergency services' network (Nødnett) and others, mainly use Telenor's transmission infrastructure, and to some extent Broadnet's. National radio and television companies rely on Telenor's transport network to get signals to transmitters.

Telenor's transport network is robust and well protected. However, in the event of any network outage there are no alternatives. Satellite telephony and radio communications do not have nearly enough capacity to meet the need for communication.

The subreport documents the consequences electronic communications outages have for the various critical societal functions.[272] The most serious are:

1. Management of the crisis at a political and administrative level becomes difficult, with reduced opportunities for communication and coordination.
2. The disappearance of radio, television and the Internet means that important information channels for the public would be unavailable.
3. Rescue efforts becomes more difficult in the absence of telephony and when the functionality of emergency numbers and the emergency services' network (Nødnett) is severely hampered.
4. Railway and air traffic would stop. Road and maritime traffic would also experience problems.
5. Failures in payment services would cause major challenges for commercial sector and the public.

Assessment of likelihood

The likelihood of intentional acts is not specifically assessed in Analyses of Crisis Scenarios.

Conducting a successful cyber attack as outlined in this scenario requires a very high level of expertise and capacity – also with regard to intelligence. It is believed that only a few actors have such capabilities.

The likelihood would depend on the international threat picture. The PST's open threat assessment for 2018 states that "[e] nterprises within the Norwegian defence and public security sector, public administration, research and development and critical infrastructure are assessed to be particularly at risk of becoming intelligence targets." This applies with respect to both network operations and more traditional intelligence gathering. Several countries' intelligence services have interests within these areas.

Assessment of consequences

Overall, the consequences of the loss of electronic communications and the consequential events are assessed as *very high*. The consequences would have a major impact on all five of the societal assets, with the exception of Nature and Culture. A more exhaustive description containing a more detailed review of the basis for the assessments can be found in the subreport.

Life and health

Reduced opportunity to notify the emergency services in the event of acute events, no possibility to call an ambulance in the normal manner, inadequate communication and coordination between the emergency services, as well as reduced efficiency and delayed treatment of patients in the health and care sector will have consequences for life and health.

The analysis is based on an assumption that around 5% of acutely sick or injured people (who would otherwise have survived) would die. This means that, overall, the scenario would result in around 10 more deaths per day, or approximately 50 deaths in a five-day period, which represents an increase of around 10% in relation to the normal daily mortality rate. A number of planned treatments would be cancelled due to reduced efficiency. During a five-day period, we estimate that 200–300 people would become significantly more ill due to reductions in the provision of treatment.

The consequences with respect to death and serious injuries and illness have been assessed as medium.

Economy

It is assumed that the direct economic losses will be NOK 2 to 10 billion and that they will mainly be associated with the necessary repair and replacement of physical components and infrastructure.

The direct economic losses have been assessed as large.

The indirect economic losses will be associated with loss of income, production losses and a decline in consumption, orders and deliveries. A functioning payment system is a prerequisite for being able to pay for the delivery of goods and services, as well as the trading of financial instruments. Around a third of the normal production, or approximately NOK 13 billion (2014),

[272] *DSB (2014). National Risk Analysis: Scenario "Cyber Attack on Electronic Communications Infrastructure" – Critical consequential events and consequences in the population.*

will be lost as a result of the loss of electronic communications. Even if some of the lost revenue can be recouped, it is assumed that the net loss will exceed NOK 10 billion.

The indirect economic losses have been assessed as very large.

Societal stability

The scenario would result in significant reactions among the public in the form of anxiety, insecurity, fear and a feeling of powerlessness. The incident would be experienced as sudden and unfamiliar. A lack of information would significantly contribute to the level of anxiety. The reactions would be reinforced by people involved in emergency situations being unable to get through on emergency numbers.

The social and psychological response has been assessed as very large.

The entire freight transport chain is dependent on online systems and large delays in the delivery of goods will arise. After a few days, people would start hoarding food, which would further exacerbate the level of anxiety. An estimated 250,000 people would experience problems and significant inconvenience due to a lack of means of payment during the period.

The halt in air traffic would affect around 450,000 passengers during the five days, while the halt in train traffic would affect around one million passengers. Transferring traffic from aeroplanes and trains to roads, would result in greater delays during peak hours.

Overall, it is estimated that the scenario would cause a very large amount of stress on daily life.

Democratic values and capacity to govern

The outage of electronic communications would cause major challenges for governance and crisis management. The event would be perceived as a significant violation of shared cultural and democratic values, as well as basic individual rights and personal safety.

The scenario would, therefore, heavily impact the societal asset Democratic Values and National Capacity to Govern.

Assessment of uncertainty

Less serious cyber attacks occur every day in Norway, and the phenomenon is well understood. However, we have no experience of a cyber attack as comprehensive as the one in this scenario, either in Norway or internationally. The attack would result in consequential incidents that would propagate through society. There is some inherent uncertainty in this.

The degree and duration of the nationwide transport network outage and how long it takes for the network to be restored to full functionality, would be critical to the severity of the consequences. The assessments are particularly sensitive to whether the failure is total or only partial.

Overall, the uncertainty associated with the assessments has been assessed as medium.

Possible measures

NOK 40 million has been allocated in the national budget for 2019 for a pilot project looking at an alternative transport network. The goal is to demonstrate solutions and opportunities for a functioning market for an alternative core network that socially critical enterprises and others could use.[273]

Otherwise, the analysis results indicate that there should be a focus on:

- the need of individual stakeholders to obtain an overview of their services' dependency on electronic communications and the vulnerability associated with this
- the need for properly thought through emergency preparedness in case of a prolonged electronic communications outage
- the municipalities' key role in meeting the public's needs in the event of a prolonged electronic communications outage

The analysis results indicate that enterprises with responsibility for critical societal functions need to:

- include electronic communications outage in their risk and vulnerability assessment
- assess whether the actual communication capacity of backup solutions would meet their needs
- obtain the necessary overview of internal electronic communications services' dependence on the nationwide transport network
- carry out exercises that include a total transport network outage

The analysis results also indicate that municipalities:

- Must consider establishing routines for internal communication within their municipality for when telephone and data networks are out of commission for several days. A system that enables the public to contact the police, emergency medical services and the fire service in emergencies is especially important. ◎

[273] *Proposition 1 S (2018-2019) Ministry of Transport.*

TABLE 29. Schematic presentation of the results from the risk analysis.

Likelihood assessment	Explanation
The likelihood of intentional acts is not specifically assessed in ACS. Only a few actors have the capacity to conduct a successful cyber attack such as the one outlined in this scenario, but there are none that are known to have such an intention.	

Consequence assessment							
SOCIETAL ASSET	**CONSEQUENCE TYPE**	**VERY SMALL**	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
Life and health	Fatalities			◎			50 additional fatalities as a result of the lack of means to notify the emergency services in the event of acute events.
	People affected by serious injuries and illness			◎			200–300 serious injuries and ill people as a result of delayed treatment or malpractice.
Nature and culture	Long-term damage to the natural environment						Not relevant.
	Irreparable damage to the cultural environment						Not relevant.
Economy	Direct economic losses				◎		Repair and replacement costs associated with destroyed system components of NOK 2–10 billion.
	Indirect economic losses					◎	Loss of income, delay costs, production losses and reduced trade result in an overall loss of approximately NOK 10 billion.
Societal stability	Social and psychological response					◎	Insufficient information from the authorities, weakened crisis management and an unknown and malicious act create unrest and anxiety.
	Stress on daily life					◎	Insufficient access to telephone and data services and means of payment. Freight and passenger transport delays.
Democratic values and capacity to govern	Loss of democratic values and national capacity to govern				◎		Attack on very important infrastructure which carries society's capacity to govern. Ability of central institutions to function is threatened. Violation of democratic values and individual rights.
	Loss of territorial control						Not relevant.
OVERALL ASSESSMENT OF CONSEQUENCES						◎	Very large consequences overall.

Overall assessment of uncertainty							
		VERY SMALL	**SMALL**	**MEDIUM**	**LARGE**	**VERY LARGE**	
KNOWLEDGE BASE AND SENSITIVITY				◎			Overall, the uncertainty has been assessed as *medium*.

19

SUMMARY OF THE RESULTS OF THE ANALYSIS

The 25 events analysed in this collated report are very different. Despite their differences, all of the scenarios have been analysed in the same way, except that no likelihood has been specified for intentional acts. It is natural to compare them in a summary chapter. The figures in this chapter illustrate such comparisons. They can provide us with some information about which events society should pay particular attention to in its preventive and emergency preparedness work. Comparisons can also tell us something about where the greatest potential for risk mitigation lies: is it high likelihood or major consequences that mainly contribute to the risk?

Even though the incidents would generally be managed by different specialist departments and sectors, comparisons across areas of responsibility can provide a better overview and enable comparisons with other countries' national risk assessments.

However, an overall risk profile for society does not render any automatic order of priority. Society cannot prioritise its resources solely on the basis of assessments of high and low risk. Another important factor in the decision-making process is whether effective risk mitigation measures exist. Is it even possible to reduce the risk with the means available and within a realistic framework?

The illustration on the previous page indicates the range of events that have been analysed in this report.

ILLUSTRATION JANNICHE CRAMER / DSB

19.1 COMPARISON OF THE LIKELIHOOD OF THE SCENARIOS

The likelihood of the 21 unintentional events that have been analysed varies greatly. Three events have a very high or high likelihood, while seven events have a very low likelihood. It is important to remember that even events with a high likelihood in ACS are relatively rare compared with other events that are normally considered serious, such as road traffic accidents and fires. A very high likelihood in ACS means that we have assessed it as at least 90 per cent likely that the event will occur in a 100-year period, ref. the method description in chapter 2. Three of the most likely scenarios are health-related: Foodborne Illness, Pandemic in Norway and Drug Shortage. Four natural events also score relatively high as far as likelihood is concerned: Flash Flooding in a City, Solar Storm, Three Simultaneous Forest Fires and Storm in Inner Oslo Fjord. Natural events dominate the middle section of the likelihood scale. Among the least likely events we find major accidents, mainly industrial accidents. Of the accident scenarios, Tunnel Fire is the most likely.

Naturally, the scenario-specific likelihood is always low, since it is a specific course of events in a specific location that is being analysed. Sometimes the same scenario could occur in other locations in the country or there can be

Likelihood per scenario

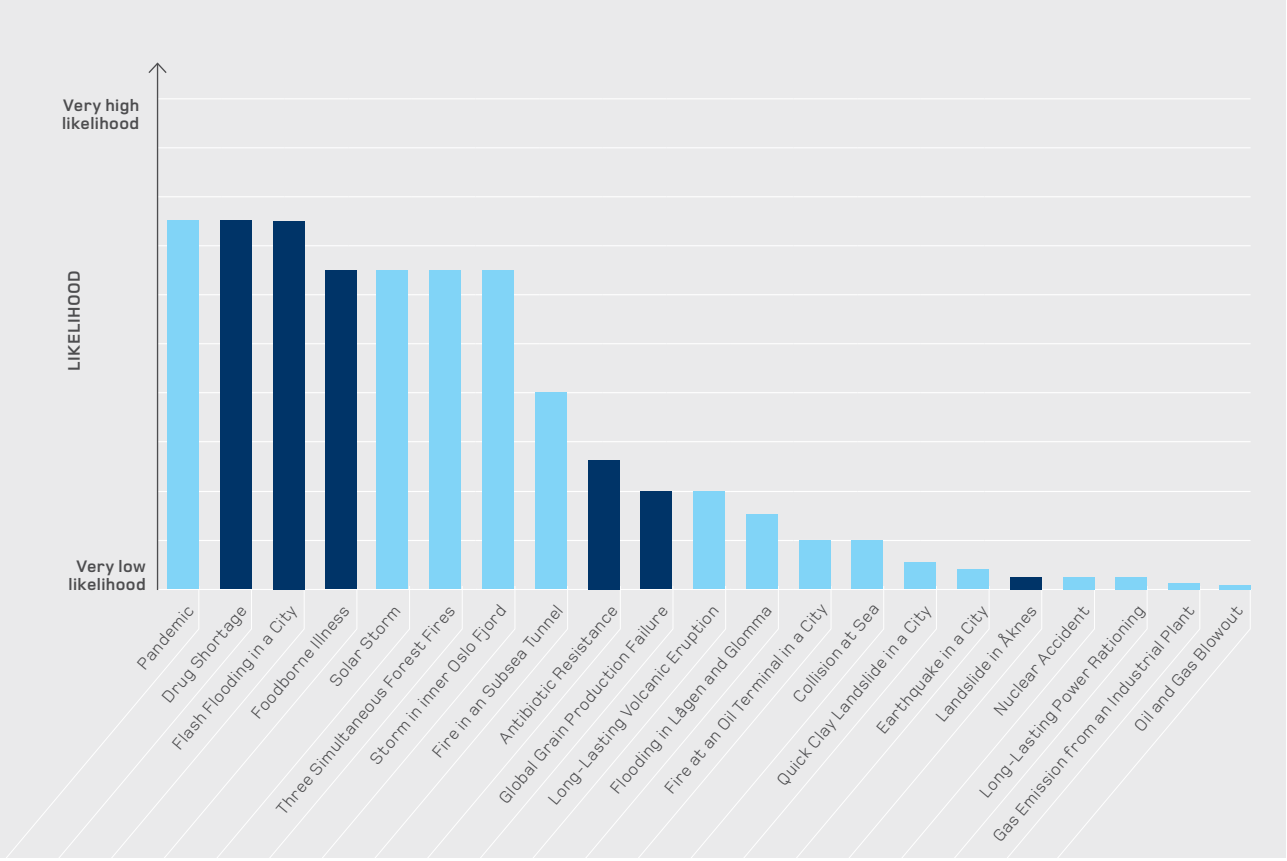


FIGURE 11. Likelihood for each of the 21 analysed unintentional scenarios. The six new scenarios that have been analysed since 2014 are marked with a darker colour.

multiple variants of the same scenario (e.g. shortage of drugs other than the two analysed in the scenario). By taking this into account, we arrive at a different likelihood for the same type of events on a national basis. The likelihood transferred to a national scale will be higher than the likelihood of the specific scenarios analysed. Transferred likelihood can be useful information for central authorities, which must prevent and manage events no matter where in the country they occur and regardless of the specific course of events.

Tunnel Fire, Flash Flooding in a City and Drug Shortage have the highest transferred likelihood.

When we assess the likelihood of a fire occurring in one of the approximately 30 subsea tunnels in Norway, the likelihood will be far higher than that for a fire specifically in the Oslofjord Tunnel.

Other events that could occur in several places and therefore have a higher likelihood on a national basis are major rockslides and flooding in major watercourses. 14 of the 21 analysed events score a moderate likelihood or higher on a national basis, while only nine of the location-specific scenarios have an equally high likelihood.

Transferred likelihood of the scenarios

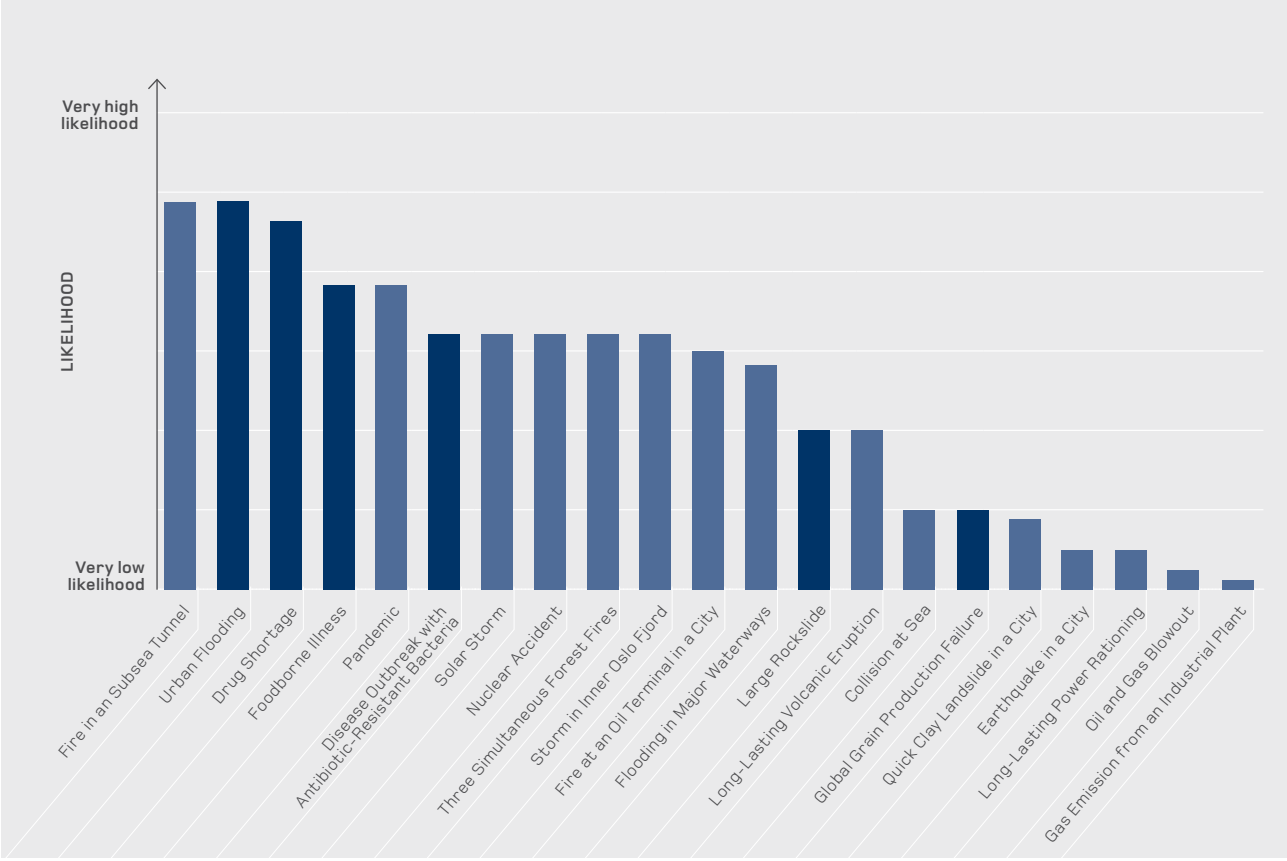
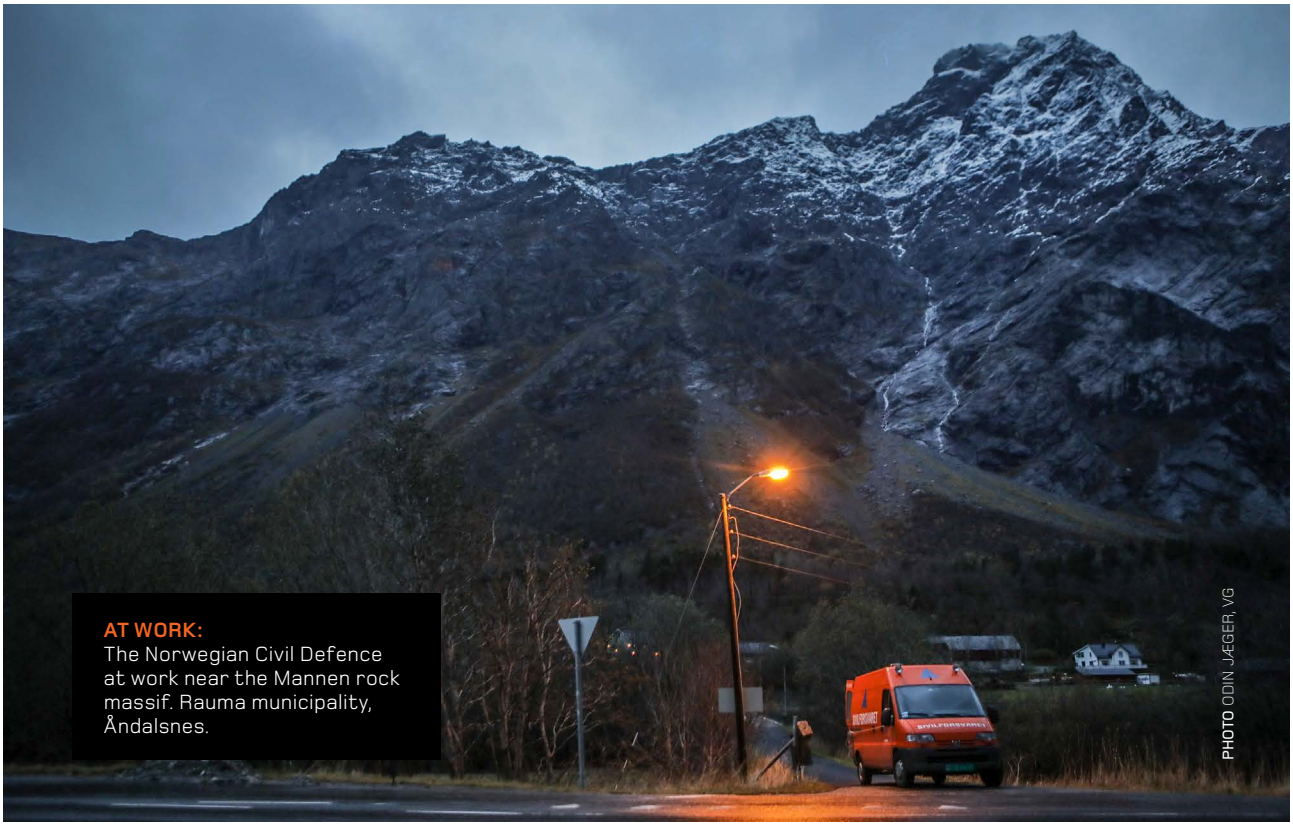


FIGURE 12. Transferred likelihood on a national basis for ACS scenarios. The latest analyses are marked with a darker colour.

PHOTO HELGE MIKALSEN, VG

FIREFIGHTING:
The Norwegian Civil Defence diligently fighting a forest fire at Elgsjø in Notodden.



AT WORK:
The Norwegian Civil Defence at work near the Mannen rock massif. Rauma municipality, Åndalsnes.

PHOTO ODIN JÆGER, VG

19.2 OVERVIEW OF THE CONSEQUENCES

The overview of consequences includes the four analyses of intentional acts, so it contains a total of 25 scenarios. The overall consequence is the sum of the scores for each of the consequence types, in which the various degrees of severity are weighted. The overall consequence is illustrated by the height of the columns in the figure below.

Five scenarios fall into the category of very large consequences: Pandemic in Norway, Earthquake in a City, Quick Clay Landslide in a City, Nuclear Accident and Cyber Attack on Electronic Communications Infrastructure. Apart from Pandemic in Norway, these are events with a very low likelihood, meaning that the overall risk is not necessarily high.[274] At the opposite end of the scale there are six scenarios assessed as having very small or small consequences. All of the six events with small consequences have a relatively high likelihood.

The colour codes on the columns illustrate the contribution of the different consequence types to the overall consequence. The consequence types Social and psychological response, Serious injuries and illness, and Direct economic losses and Indirect economic losses are the ones that contribute most to the overall consequence. The smallest contribution to the overall consequence is naturally made by Loss of democratic values and national capacity to govern, which is only relevant for the intentional events. Loss of territorial control is not a relevant consequence in any of the current analyses.

It is particularly the scenarios Pandemic in Norway, Nuclear Accident and Drug Shortage that have consequences for Life and health. Three natural events have the greatest consequences for the cultural environment, namely Earthquake in a City, Quick Clay Landslide in a City and Rockslide in Åknes. The accident scenarios, Nuclear Accident, Oil and Gas Blowout and Collision at Sea Off the Coast of Western Norway, have the greatest consequences for the natural environment.

Major accidents and natural events have almost equally large economic consequences, while intentional acts and supply failures have relatively small economic consequences (apart from Cyber Attacks on Electronic Communications Infrastructure). On the other hand, intentional acts and supply failures have the greatest consequences for Societal stability.

[274] *The likelihood of intentional acts has not been assessed.*

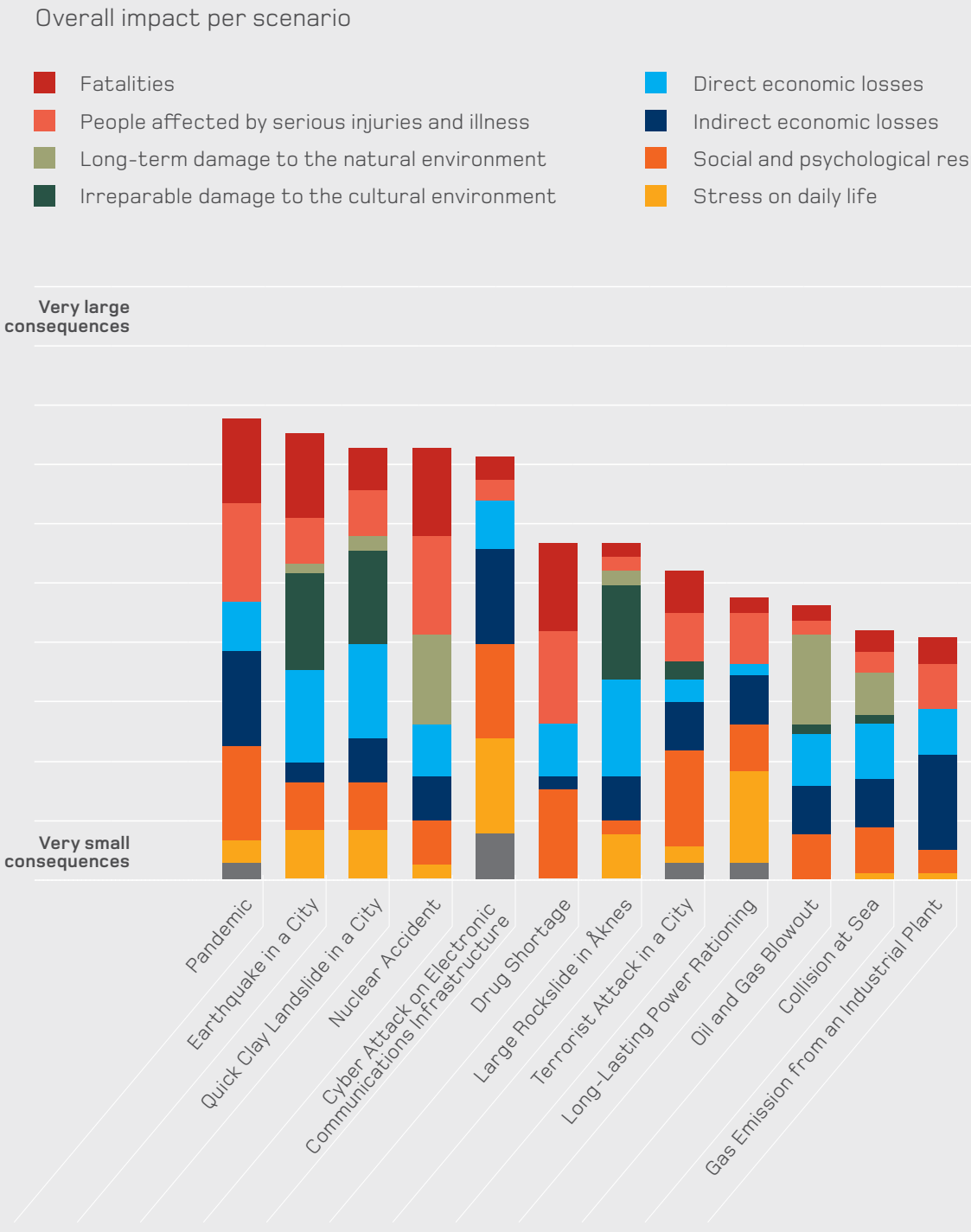
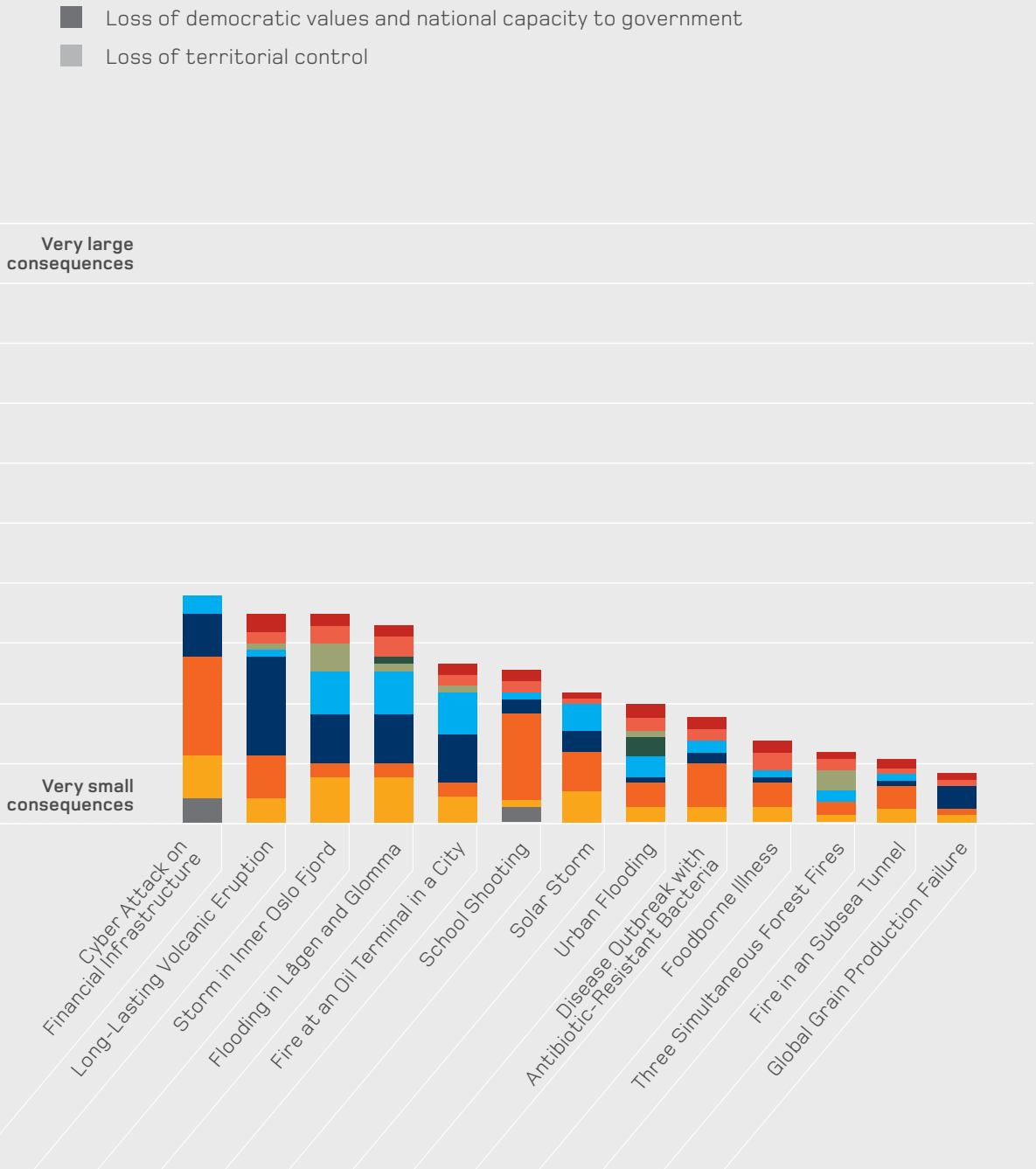


FIGURE 13. Overall impact per scenario, broken down by the contributions from the eight different types of consequences.


Loss of democratic values and national capacity to government
Loss of territorial control
Very large consequences
Very small consequences
Cyber Attack on Financial Infrastructure
Long-Lasting Volcanic Eruption
Storm in Inner Oslo Fjord
Flooding in Lågen and Glomma
Fire at an Oil Terminal in a City
School Shooting
Solar Storm
Urban Flooding
Disease Outbreak with Antibiotic-Resistant Bacteria
Foodborne Illness
Three Simultaneous Forest Fires
Fire in an Subsea Tunnel
Global Grain Production Failure

19.3 RISKS ASSOCIATED WITH THE SCENARIOS

A matrix with scenario-spesific likelihood along one axis and consequences along the other can provide a simplified picture of the overall risk profile constituted by the scenario analyses. In the matrix below, both axes have a five point scale from very small to very large consequences, and from very low to very high likelihood, respectively. The matrix is divided into a grid (5x5) in which the events in the same square have almost identical risk.

The matrix presupposes an understanding of risk as being a combination of likelihood and consequences, and uncertainty is not expressed. Events in the bottom left of the matrix have the lowest risk, while events in the top right have the highest risk. This presentation of risk cannot simply be used as a list showing an order of priority for which events measures should be implemented to counter. There are a number of other considerations that responsible competent authorities have to take account of before deciding any risk mitigation measures.

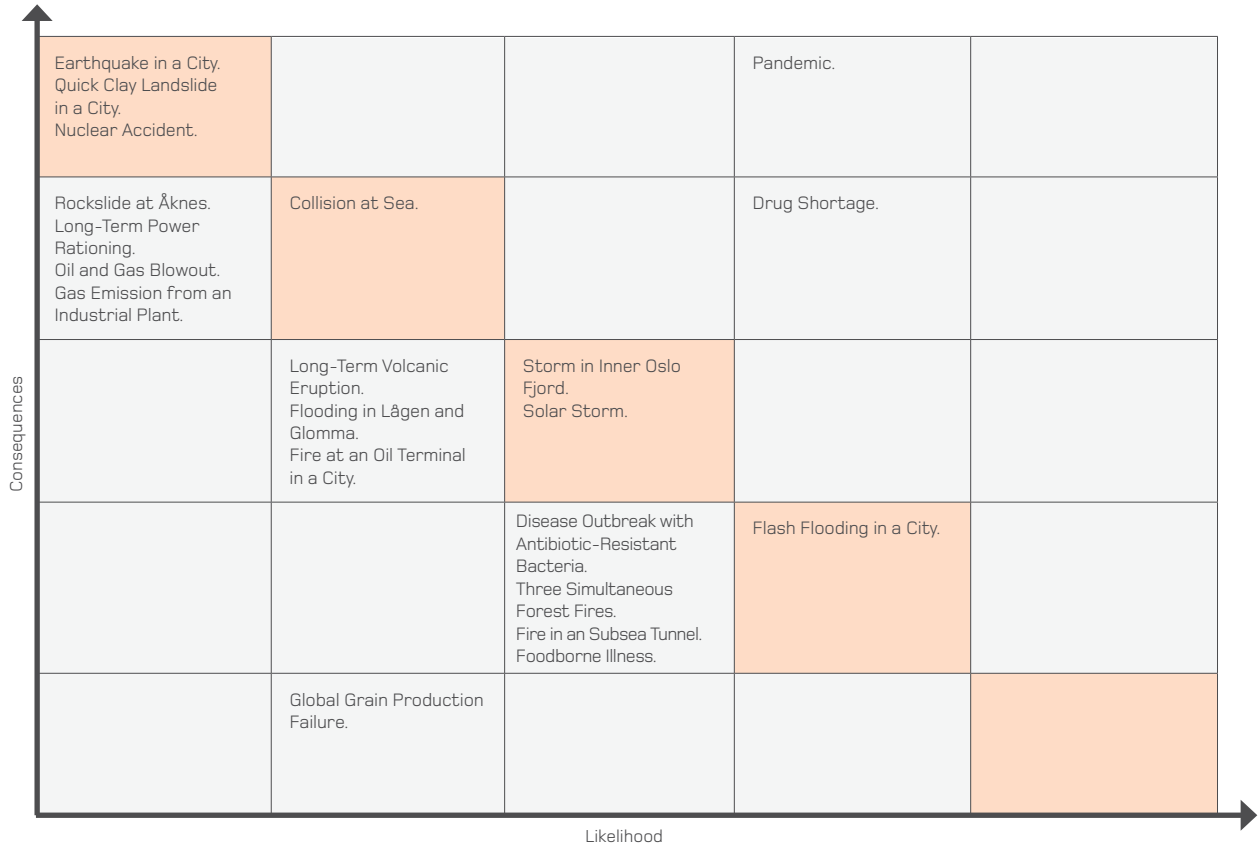


FIGURE 14. Risk matrix with the 21 analysed unintentional scenarios in ACS. Intentional acts are omitted in the matrix. Events in the same square have approximately equal risk.

The matrix shows that Pandemic in Norway and Drug Shortage are the scenarios with the highest overall risk. These are followed by Foodborne Illness.

The Earthquake in a City, Quick Clay Landslide in a City, Nuclear Accident, Collision at Sea, Storm in Inner Oslo Fjord, Solar Storm and Flash Flooding in a City scenarios lie along the same diagonal in the middle of the matrix and are estimated to have approximately equal and moderate risk. Global Grain Production Failure stands out as having the lowest estimated risk.

19.4 POTENTIAL RISK MITIGATION

When prioritising risk mitigation measures, one must take account of both the risk the events represent and whether or not effective measures exist that are practical and economically feasible to implement. This involves assessments of the measures' risk mitigation effect and cost-effectiveness. In some cases it may be sensible to implement cheaper measures to counter events with a relatively low risk, rather than expensive measures to counter events with a higher risk.

One approach to assessing the potential risk mitigation of a measure is to survey:

- The degree to which new risk mitigation measures exist.
- Whether or not multiple independent measures exist.
- How great the risk mitigation effects of the measures are.
- How expensive the measures are.
- Which positive and negative side-effects the measures have.
- The degree to which the authorities responsible can independently decide to implement the measures or whether they depend on decisions by others.
- How durable and reliable the measures are over time.

Combining potential risk mitigation and the risk of events occurring will provide a more nuanced approach to prioritising measures than risk alone. An assessment of measures in relation to risk level helps to ensure relevant follow up of the risk analysis and is a risk management tool. Such a tool will give authorities a better basis for decision making on risk mitigation than the risk matrix alone.

Even though the goal is to mitigate risk by implementing effective measures, some residual risk will remain that, in practice, society must accept, since the costs of further risk mitigation are considered too high. This is not just about economic costs, but also costs in the form of reduced freedom and other basic rights and goods. ◎

APPENDIX

APPENDIX 1: SUPPLEMENTARY QUESTIONS FOR THE ASSESSMENTS IN THE RISK ANALYSES

ASSESSMENTS	RISK ELEMENTS				POTENTIAL RISK MITIGATION
	Likelihood	Consequences	Vulnerability	Uncertainty	
Main question	How likely is it that the event will occur in a 100-year period?	What consequences can the event have for the societal assets?	How well would the system cope with the event occurring or prevent it from resulting in serious consequences?	How good is the knowledge base for the analysis? How sensitive are the results to changes in assumptions?	Do (unused) risk mitigation measures exist?
Supplementary questions	• What preconditions must be present for the event to occur? • To what extent are these preconditions present?	• What losses would the event cause for each of the ten consequence types?	• What is the system dependent on to function? • How reliable are these deliveries? • How complex is the system? (supply chain?) • To what extent have effective barriers and redundancy been established? • Would the event cause consequential events, or failure in critical societal functions? • To what extent could the system retain its functional capabilities?	• How well understood is the phenomenon being analysed? • How good is the knowledge base? • Is there consensus among the experts? • To what extent will small changes in the assumptions have a major impact on the analysis results?	• What measures exist? • What effect do they have? • Do the measures work independently of each other? • How realistic is an implementation of the measures (costs etc.) • To what extent can the responsible authority independently decide to implement the measures?
Scoring	Percentage likelihood in a 100-year period	Number, extent, duration, indicators	Effect on likelihood and consequences	From very small to very large	From very little degree to very large degree
Scale	1–5	1–5		1–5	1–5

TABLE 30. Checklist for use in the risk analyses in ACS.

APPENDIX 2: INDICATIONS OF LIKELIHOOD FOR EVENTS IN ACS 2019

THE SCENARIOS PLACED IN A RISK MATRIX	ANNUAL LIKELI-HOOD (%)	LIKELI-HOOD 100 YEARS (%)	MEAN VALUES AND ROUNDING OFF (%)	CATEGORIES (1-5)
Pandemic	1,5	75,1	75	High
Drug Shortage	1,5	75,1	75	High
Flash flooding in a City	1,5	75,1	75	High
Foodborne illness	1	63,4	65	Moderate
Solar Storm	1	63,4	65	Moderate
Three Simultaneous Forest Fires	1	63,4	65	Moderate
Storm in inner Oslo Fjord	1	63,4	65	Moderate
Fire in an Subsea Tunnel	0,5	39,4	40	Moderate
Disease Outbreak with Antibiotic-Resistant Bacteria	0,3	24,9	25	Low
Global Grain Production Failure	0,2	18,1	20	Low
Long-Term Volcanic Eruption	0,2	18,1	20	Low
Flooding in Lågen and Glomma	0,15	13,8	15	Low
Fire at an Oil Terminal in a City	0,1	9,5	10	Low
Collision at Sea	0,1	9,5	10	Low
Quick Clay Landslide in a City	0,04	4	4	Very low
Earthquake in a City	0,03	3	3	Very low
Landslide in Åknes	0,02	2	2	Very low
Nuclear Accident	0,02	2	2	Very low
Long-Term Power Rationing	0,02	2	2	Very low
Gas Emission from an Industrial Plant	0,01	1	1	Very low
Oil and Gas Blowout	0,0002	0,02	0,02	Very low

SCALE FOR LIKELIHOOD IN A 100-YEAR PERIOD	INTERVALS	NUMBER OF SCENARIOS PER CATEGORY
Very high	90–99 %	0
High	70–89 %	3
Moderate	40–69 %	5
Low	10–39 %	6
Very low	0–9 %	7

ROUNDING OFF RULES	
Under 10	Not rounded off
Over 10	Rounded off to nearest 5

TABLE 31. Likelihood assessments in ACS 2019.

APPENDIX

NOTES

NOTES

NOTES

NOTES

NOTES

Norwegian Directorate for Civil Protection

Rambergveien 9
3115 Tønsberg

Phone 33 41 25 00

postmottak@dsb.no
www.dsb.no

ISBN 978-82-7768-510-6 (PDF)
HR 2436

/DSBNorge

@dsb _ no

dsb _ norge

dsbnorge