National Risk Profile (NRP)

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The Danish Emergency Management Agency (DEMA)
Datavej 16
3460 Birkerød
Denmark
Tel.: +45 45 90 60 00
Fax: +45 45 90 60 60
E-mail: brs@brs.dk
www.brs.dk

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Foreword

Welcome to the first edition of the National Risk Profile. The report describes the most serious natural and man-made risks from a Danish viewpoint.

When the emergency services deploy, it is often in response to minor accidents, and we are accustomed to living in a society with a functioning infrastructure and where the security of supply is high.

However, we should not be blind to the fact that major accidents and disasters do occur in Denmark. That is why we have a crisis management system with crosscutting staffs at the central, regional and local levels. It is also why DEMA, as a central part of Denmark's disaster preparedness, retains specialized equipment and personnel that can be deployed when the capacity of normal emergency services are no longer sufficient.

In the National Risk Profile, we focus on 10 incident types whose common feature is that they can cause major accidents and disasters in Denmark. Whenever these occur, they can result in grave consequences for life, health and well-being; we can experience severe damage to property and the environment; and we may suddenly find that critical infrastructure breaks down or comes under extreme pressure. Last but not least, major accidents and disasters cost society a great deal of money: one need only recall that the cloudburst of 2 July 2011 resulted in damage worth over DKK 6 billion.

The National Risk Profile shows that the risks that are characteristic of our present-day society are complex, often indifferent to borders, and constantly changing. We must therefore have a robust preparedness against major accidents and disasters. We must work determinedly with prevention, so that both the likelihood and the consequences of incidents may be reduced as far as possible. But prevention is not the answer to everything. There will always be extreme incidents which cannot be prevented. We must therefore also be prepared to generate an effective concerted operational response and crisis management across organisations and administrative levels and across the public and private sector.

At DEMA, we are well aware that unpredictability is a constant factor in all major accidents and disasters. We do not know what will happen, where or when. Neither do we know precisely how a given situation will develop. Nonetheless, I am convinced that, when we apply ourselves in earnest to preparedness planning and crisis management with regard to known incident types, we shall also have an advantage in dealing with the unknown, unforeseen or unpredictable accidents and disasters.

The National Risk Profile gives an idea of the challenges we face from the 10 incident types that it singles out. The risk profile thus makes a good common starting point for our preparation and development of the emergency preparedness, and is to be seen as a new contribution to the planning assumptions of society's collective preparedness.

Henning Thiesen
Director

1. Introduction

Background

DEMA continuously seeks to keep abreast of, to highlight and to disseminate knowledge of risks that may lead to major accidents and disasters. In practical terms, we gather information which can tell us about the characteristics and causal relations of each risk, how the overall risk picture currently looks, and how it may develop in future. Some risks are relatively easy to identify and monitor because they regularly trigger incidents or generally attract attention. In other cases, it requires greater perceptiveness to spot new risks or new ways in which familiar risks may develop.

The National Risk Profile (NRP) is a result of this continuous effort to map and analyse risks. The NRP does not cover the whole range of risks confronting Danish society, but concentrates on those which DEMA believes have the greatest claim on the attention of preparedness planners and operators at the moment.

The NRP has been drawn up partly on DEMA's own initiative, partly following a request by the EU that its Member States should develop national risk assessments. This request is set out in the European Council's conclusions of April 2011 on *Further Developing Risk Assessment for Disaster Management within the European Union*. The NRP thus meets a twofold need, European as well as national.

Objectives

The NRP aims to provide an overview of the most serious natural and man-made risks from a Danish viewpoint. At the same time, it is intended as a contribution to the preparedness planning assumptions among organisations – both within different sectors, across sectors, and at the central level of the national crisis management system. Among other things, the NRP can be useful in connection with activities such as risk and vulnerability analyses, capacity analyses and capacity planning, the drawing up or revision of preparedness plans, and preparedness-related training and exercises. Furthermore, the NRP corroborates DEMA's guide *Comprehensive Preparedness Planning* and other materials to be found on brs.dk.

Method

In this first edition of the NRP, DEMA has endeavoured to provide an overview by means of an informative and easily readable report, free from detailed and cumbersome methodological reflections. The method is principally qualitative, since reliable quantitative data seldom exist for the incident types that it deals with.

Focus in the NRP is on assessing the possible consequences of the selected incident types rather than the likelihood of their occurrence. Our account is therefore limited to what may happen, and must not be interpreted as an attempt to foretell where, when, how often, why or exactly how it will happen. Extraordinary incidents are by definition hard to predict, and the way they play out will almost always surprise. For the same reason, the NRP adopts a descriptive approach, with emphasis on historical documentation of real incidents that have affected Denmark in the past, instead of constructing scenarios around fictitious incidents. While the past cannot be used to foretell the future, previous experience can often be a source of valuable insights and important lessons regarding the likely consequences of future incidents. To readers interested in a scenario-based approach, we recommend, inter alia, DEMA's *Model for Risk and Vulnerability Analysis* from 2005 and *the Scenario Bank*, comprising 22 examples from 2006, likewise available at brs.dk. It is also worth mentioning that specific scenario analyses have been conducted on a number of occasions by state, regional and local authorities and by companies responsible for critical infrastructure.

2. The selected incident types

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The NRP deals with a total of 10 incident types, divided into two main categories and four sub-categories.

Natural incidents	
Extreme weather phenomena	*Serious contagious diseases*
1. Hurricanes, strong storms and storm surges 2. Heavy rain and cloudbursts	3. Pandemic influenza 4. Animal diseases and zoonoses
Man-made incidents	
Accidents (unintended actions, technical errors, etc.)	*Security threats (intentional actions)*
5. Transport accidents 6. Accidents with dangerous substances on land 7. Marine pollution accidents 8. Nuclear accidents	9. Terrorist acts 10. Cyber-attacks

Selection process

When beginning work on the NRP, DEMA first drew up a provisional 'gross list', where a larger number of incident types were considered, and then a 'net list' containing the 10 selected incident types. Among the ones excluded, of which some may yet be included in updated versions of the NRP, were the following:

Natural incidents	*Man-made incidents*
• Heat wave • Hard winter • Blizzard and heavy snowfall • Sudden violent thawing with major floods • Meteorite impact in/near Denmark • Tsunami hitting Danish coasts after a seabed displacement off Norway or an earthquake under the Atlantic Ocean. • Solar storm causing magnetic and electric disturbances to satellite-based ICT and energy infrastructure • Explosive volcanic eruption abroad spreading ash into European, including Danish, airspace, and resulting in prolonged disruption of air traffic • Effusive volcanic eruption abroad spreading poisonous gases to Denmark and greatly endangering human, animal and plant life	• Prolonged and geographically extensive power outage from grid and power plant failure due to factors within the electricity sector • Breakdown of electronic payment systems • Pollution of drinking water • Supply failure due to strike or blockade • Structural collapse due to construction faults in high-rise buildings, stadiums, traffic infrastructures, etc. • Man-made fire in large building or nature area • A satellite crashing on Danish territory • Episode of widespread civil disobedience, violent activism, vandalism, arson, etc. • Armed clashes between organised criminal gangs • Espionage incident harming national interests • Act of war against Denmark

The selection process was wide-ranging, in part because the consequences of one incident can be the cause of another. For instance, it was difficult to decide whether power outages should be included in the NRP as a primary incident type – i.e. caused by human or technical failings within the electricity sector – or only be mentioned in other sections of the report as a secondary, derived consequence of incidents included in the NRP, e.g. extreme weather phenomena, various major accidents or terrorist acts.

Selection criteria

An important criterion for the selection was that the consequences of the incident types can be very considerable in magnitude, geographical extent and/or duration seen from a national perspective. The consequences should not be manageable at a local administrative level alone but demand external emergency response assistance. The consequences should broadly be detrimental to values such as life, health, well-being, property, the economy, the environment and one or more critical societal functions. The term 'critical societal functions' refers in this context to those activities, commodities, services, etc. that underpin society's general ability to function.

Since the report constitutes a national risk profile, another essential criterion was that all the consequences should be able to manifest themselves within Denmark's borders. Consequently, incident types unlikely to occur in or near Denmark, e.g. major earthquakes, were left out the report, even though they may impinge on Danish citizens and Danish interests abroad. Similarly, risks of a more global, diffuse or long-term nature were excluded, e.g. financial crises, international armed conflicts, proliferation of weapons of mass destruction, or scarcity of natural resources due to population growth, urbanisation, climate change, etc.

For the purpose of identifying the possible consequences, DEMA used the following checklist:

Harm to life, health and well-being	*Harm to property and economy*	*Environmental harm*
☐ Dead	☐ Material damages	☐ Land pollution
☐ Injured	☐ Financial losses	☐ Water pollution
☐ Ill/infected/contaminated	☐ Loss of intellectual property rights	☐ Harm to animals
☐ Anxiety/insecurity/fear	☐ Destruction/loss of cultural heritage	☐ Harm to plant life

Failure of or extreme pressure on the availability of critical societal functions
☐ Energy: Supply of electricity, natural gas, crude oil, fuel, etc.
☐ Information and communications technology (ICT): Phone, internet, information networks, processing and transmission of data, navigation, satellite/radio/TV transmission, post and courier services, etc.
☐ Transport: Carrying out, monitoring and controlling passenger and cargo transport (road, rail, air and sea), monitoring and controlling of infrastructure (bridges, tunnels, stations, airports, harbours), etc.
☐ Water: Supply of drinking water and waste water disposal.
☐ Food: Supply of food, supervision of food safety, monitoring and responding to contagious animal diseases and zoonoses.
☐ Finance: Money transmission and transfer services, banking and insurance, securities trading, etc.
☐ Fire and rescue services, police tasks, military assistance to civil authorities, etc.: Alarming and alerting, on-scene coordinating and technical incident command, cordoning off, fire fighting, search and rescue (land/sea/air), evacuation (incl. reception, housing and catering), environmental pollution response, storm surge preparedness, snow-preparedness, public order enforcement, explosive ordnance disposal, control of production, storage and transport of hazardous materials (chemical, biological, radiological, nuclear, explosive), and response to incidents that do or may involve hazardous materials.
☐ Health and social services: Prehospital services, hospitals, practising physicians, production and distribution of pharmaceuticals, supervisory systems, day-care and residential institutions, home care, etc.
☐ Defence, intelligence and security services: Military defence and enforcement of sovereignty, counter-terrorism, counter-extremism, counter-espionage, personal protection, etc.
☐ Exercise of authority (all levels): Crisis management capacity, maintenance of parliamentary, governmental, central administrative, judicial, municipal and regional authority.

Approach

The consequences of the incident types described in the NRP can affect different sectors and involve many actors. DEMA's selection and description of the incident types have therefore been carried out in consultation with experts from sector-responsible government agencies and other organisations. However, it must be stressed that DEMA alone is responsible for the descriptions, assessments and comparisons contained in the report.

Besides input from and quality control by Danish experts, DEMA has, inter alia, drawn inspiration from foreign reports that are to a certain extent comparable, such as the Norwegian, Swedish, Dutch and British national risk assessments of 2011 and 2012. Inspiration has also come from participation at the European Commission's expert group meetings on risk assessment.[1]

The risks that characterise our present-day society are more complex than in the past, they often have a cross border dimension, and they are constantly changing. DEMA will therefore further develop and update the national risk picture at appropriate intervals.

As a publication, the NRP supersedes *National Sårbarhedsrapport* [National Vulnerability Report], which DEMA issued in the years 2005-2010. The NRP serves the same principal purpose of promoting the preparedness culture in both the public and the private sector by drawing attention to incidents that may call for extraordinary large and concerted emergency responses. At the same time, the NRP supplements a series of other DEMA products and activities to do with preparedness planning, etc., e.g. guidelines, evaluations, courses, exercises, statistics, inspection and advice.

Structure of the report

The following sections on the 10 selected incident types in the NRP all share the same structure:

- An introduction to the characteristics of the particular incident type, including possible causes.
- A description of possible consequences in case an incident of the particular type occurs.
- An account of examples of concrete incidents that have previously affected Denmark.
- An analysis of possible trends that may influence the risk associated with the incident type in the future.

The report is concluded with a comparison of the 10 incident types by means of visual representations, which illustrate DEMA's assessment of their relative position in the national risk picture.

[1] It should be noted, that DEMA does not wish the first edition of NRP to appear methodologically cumbersome, and has therefore chosen not to use the method and terminology contained in the European Commission's *Staff Working Paper on Risk Assessment and Mapping Guidelines for Disaster Management* and in *ISO 31000:2009 – Risk management*. Hence, whenever the word "risk" occurs in the NRP, it does not refer to a technical definition of the risk concept. Instead, the word – as is usually the case in day-to-day speech – is used in a more general manner to denote types of incidents or circumstances, which may result in undesired consequences. It should further be noted, that reflections on preparedness capability vis-à-vis the described risks appear some places in the report, but that the NRP is not intended to provide a comprehensive survey of preparedness in Denmark, identify specific examples of robustness or vulnerabilities, or to make recommendations to specific organisations regarding possible initiatives in their preparedness planning.

2.1. Hurricanes, strong storms and storm surges

Characteristics

Hurricanes and storms are powerful whirling winds produced by low atmospheric pressure. For these low-pressure-whirls to be defined as hurricanes, they must blow at a mean wind speed of over 33 metres per second (m/s). For a storm, the mean wind speed must be between 25 and 33 m/s. During the strongest storms, wind gusts of hurricane strength may occur but without the storm being classed as a hurricane.

In Danish latitudes, hurricanes and strong storms are nearly always associated with intense low pressure developments in areas where the atmosphere is dominated by wide variations in temperature – e.g. where cold air from the north encounters warm air from the south. The collision of cold and warm air masses forms a front, and a disturbance (whirl) on this front can lead to a low pressure which, in turn, can rapidly grow into a sizeable, unified, rotating system of winds around the low-pressure area. The greater the difference in temperature between the cold and warm air, the more violent the low pressure development can be with the accompanying wind strengths that distinguish hurricanes and strong storms. Those hurricanes and strong storms that hit Denmark usually originate along the polar front. The conditions that produce them exist most often in autumn and winter. The Danish Meteorological Institute (DMI) has registered 76 storms and hurricanes in Denmark since 1950, and 48 – or 63 pct – of these have occurred during the winter months.

A storm surge is a flood caused by an extremely high sea water level due to stormy weather. For the term "storm surge" to apply, the extreme sea water level and the resulting flooding must statistically occur less than once in 20 years (a 20-year event). The Wadden Sea coast is the most exposed area, but other low-lying areas along the west coast of Jutland are also affected. Under extreme conditions, wind in the North Sea is known to be able to increase the sea water level by up to 5-6 metres. In the Wadden Sea, heightened water level, in which the effect of wind accounts for 2-2.5 metres, occurs a few times every year.

Storm surges in the inner Danish waters are typically smaller-scale, and a water level of 1-1.5 metres above normal is regarded as a storm surge in Kattegat and the Belt Sea. In these inner waters, a storm surge is due not only to local wind conditions but also to those in the North Sea or the Baltic, far away from the heightened water level. For instance, a prolonged storm blowing from the west over the North Sea can drive water into Kattegat and onward through the Belts. Likewise, a storm from the north-east over the central Baltic can drive water out through the Belts. Funen, Zealand and other Danish islands act as barriers against the flow, and the water masses may therefore accumulate in the Belt Sea, at times even without stormy weather in the area. If wind has driven quantities of water from the North Sea into the Baltic and the Gulf of Bothnia beforehand, the wind can, when it slackens or shifts on the rear of a low pressure, produce a "bath-tub effect", in which the water flows back, causing significant storm surges on western shores of the Baltic.

Besides the strength and direction of the wind, the gravity of a storm surge in Denmark depends on whether it culminates at high or low tide. The North Sea coast experiences tide twice in 24 hours when the tidal wave travels from south to north. The highest tide occurs in the Wadden Sea, with a difference from low tide of almost 2 metres. Further up along the North Sea coast, the tidal wave falls off considerably, with a water level fluctuation of less than half a metre at Hanstholm. The tide weakens further when passing through Skagerrak, Kattegat and the Belt Sea and dwindles into insignificance south of the Belts and in the Baltic.

Possible consequences

Hurricanes and strong storms have a violent effect on everything in their paths, and can cause injuries and fatalities due to flying objects, tumbling trees, falling roof tiles and traffic accidents. Staying outdoors or being in traffic can therefore pose a deadly peril both during and immediately after hurricanes and strong storms. People and animals can also be killed, hurt or trapped when weak structures collapse. There may be further consequences for life, health and well-being if access to urgent police, fire and rescue and medical services is affected – e.g. due to adverse traffic conditions for first responder vehicles and home care personnel or due to breakdown of infrastructure.

In coastal areas, hurricanes and strong storms can result in storm surges, in which sea water rushes ashore and floods urban and rural areas. Like the powerful wind, these floods can pose a deadly danger to people and animals and, in some cases, necessitate evacuation.

Human health and well-being can also be affected when hurricanes, strong storms and/or storm surges cause power outages. The heating of most homes depend on the availability of electricity, which thus becomes especially important in winter, and the water supply and waste water disposal systems likewise depend on electricity. Power outages can thus present problems for elderly and/or ailing citizens in particular, which will require help and support from local home care services. There are also chronically ill citizens living in their own homes whose lives depend on electrically powered equipment. Moreover, animal welfare can be affected on farms not protected by emergency power sources for ventilation systems, milking machines, etc.

Hurricanes and strong storms cause considerable material damage, both as a direct effect of the wind and indirectly due to flying or falling objects. A survey conducted by the Danish Insurance Association in 2012, for instance, showed that approximately one in every 10 house owners in Denmark had suffered storm damage within the last five years. Total losses, i.e. where entire roofs and/or outer walls collapse, are not uncommon. In addition, widespread damage will often occur in the countryside, where whole forests areas are hit by windfall. The extent of damage and the subsequent expense of clearing, repairs and reforestation can mean significant economic losses.

Storm surges, too, can cause considerable material damage to or loss of property and pollution can occur from overflowing sewage systems, flooded industrial plants, leaking tanks, etc. As such, many of the possible consequences of storm surges are the same as those outlined below in section 2.2 regarding heavy rain and cloudbursts.

Hurricanes, strong storms and storm surges will typically have a serious effect on the transport sector, since bridges, airports and ferry routes will often have to be closed, and major roads and railway lines can become blocked. On land, transport must often be suspended on account of the risk of flying or falling objects, etc. At sea, the wind can make huge waves posing a danger to sailing and shipping. In addition, both strong winds and flooding may disrupt the electricity supply. The risk of widespread power outages due to the blowing down of masts with cables has, however, been reduced significantly over the past decade, where the greater part of Denmark's electricity distribution network has been dug underground. The cable-laying for the low-voltage network is expected to be completed in 2015. Finally, IT and telecommunication services may be broken off or overloaded by the number of users during hurricanes, strong storms and storm surges, with consequences for a whole series of other important or critical societal functions.

Past occurrences

Genuine hurricanes have been recorded only five times in Denmark over more than 100 years, but there have been several strong storms which fell just short of a mean wind speed over 33 m/s and so are not classed as hurricanes.

The first 20th-century hurricane in Denmark occurred on 25-26 December 1902, causing large-scale destruction in a wide belt stretching from north-west Jutland to Himmerland and down across Zealand and Bornholm. The mean wind speed was measured at approximately 35 m/s, and it is assumed that there were gusts with an approximate speed of 50 m/s. The next hurricane happened on 23-24 October 1921 and is often called the "Ulvsund hurricane" because it wrecked the steamship *Ulvsund* in the Sound between Denmark and Sweden, killing 17 people on board. 46 years then passed before Denmark was again hit by a hurricane, on 17-18 October 1967. This time, the areas worst affected were south-west Jutland, Funen and surrounding islands, where the mean wind speed exceeded 35 m/s. The measuring instruments of the time were not equipped for such powerful winds, and several anemometers stopped at 40-42 m/s. The cost of the overall damage wrought by the hurricane, including immense devastation in forests from southern Jutland to Bornholm, was estimated at about DKK 250 million.

On 24-26 November 1981, Denmark experienced another hurricane, with a mean wind speed of 35 m/s and gusts approaching 45 m/s on the west coast of Jutland and in north-western Zealand. This hurricane was exceptionally protracted by Danish standards, and so caused more destruction and longer closures of roads, railways, ferry services, etc. In the North Sea, a rescue helicopter struggled for hours to save seven fishermen, one of whom nonetheless perished. At the same time, the wind from the North Sea brought about storm surges, and at Esbjerg the water level was at one moment measured as 4.33 metres above normal, which was the century's highest recorded figure. Esbjerg Port was completely flooded, causing large economic consequences, partly because 15,000 fish-boxes and their contents were swept out into the harbour. The island of Mandø in the Wadden Sea was 90 pct underwater, whereby 250 sheep and 25 cattle drowned. On the island of Fanø, a ferry was thrown up on to the quay, and residents of Nykøbing Mors had to be evacuated because of the floods. Once again, Denmark's forests were hit badly, especially Rold Forest in Jutland and Gribskov in Zealand, where approx. 3 million cubic metres of wood were lost. The total cost of the hurricane is estimated at close to DKK 900 million.

The hurricane of 3-4 December 1999 was unquestionably Denmark's biggest in recent times. Southern Jutland and the Wadden Sea were hit particularly hard, along a belt of some 100 km, but the hurricane affected the whole country, and, with the exception of northern Jutland, gusts attained speeds of 40-50 m/s in most places. A Danish record was set on the island of Rømø with mean wind speed at over 40 m/s and gusts at over 50 m/s before the anemometer blew down. This is reckoned to be near the maximum that can be expected for a violent low-pressure storm in and around Denmark. Although it was low tide when the wind was at its strongest, storm surges occurred at west Jutland and Wadden Sea coastlines. This time, the water level at Esbjerg rose by 3.98 metres, which was the fourth highest since official measurements began in the 1890s, but further south, at Ribe, a water level of approx.5.5 metres above normal was reached before the gauge broke down. Had the storm surge coincided with high tide, the water level might have been 1-1.5 metres higher still. Nationwide, seven people were killed and more than 800 were injured seriously enough to seek medical assistance. About 400,000 homes were without electricity for shorter or longer periods. Close to 4 million cubic metres of wood were lost to windfall in forested areas. At Lindø Shipyard near Odense, a 114-metre high portal-crane was overturned and hit a docked container ship. In total, the hurricane is reckoned to have caused damage costing about DKK 13 billion.

Since 1999, there have been no country-wide hurricanes in Denmark, but on 8 January 2005 the country was hit by a particularly strong storm with gusts of hurricane-like force and with hurricane-like local mean wind speeds in northern and western parts of the country. This storm cost four people's lives: two were killed when hit by a torn-off roof and the other two after trees fell onto their cars. A combination of high tide and powerful west wind produced a storm surge resulting in floods on the west coast of Jutland and in the

Limfjord. A number of dykes collapsed and hundreds of people had to be evacuated from the worst-hit areas, such as Thy, Løgstør and Skive. Throughout large parts of the country, the storm also had serious consequences for traffic, since bridges were closed and train, bus, metro and flight operations were halted. It is estimated, that about 4,000 people were left stranded at bus stops and stations in this connection, and there were cases of people being forced outside despite the dangerous weather when shops and department stores closed at the same time as public transport came to a standstill. About 200,000 consumers lost electricity for shorter or longer periods due to the storm, although the power outages were fewer than during the 1999 hurricane, partly because extensive cable-laying for the low-voltage network had been carried out. Several telephone exchanges and large parts of the mobile telephone networks were also out of action for a while. In the Danish forests, more than 2 million cubic metres of trees were blown over. The damage is estimated at around DKK 4 billion in total.

Possible trends

Three big storms have hit Denmark in the period since 2005, but none of them are categorised as either a hurricane or a strong storm. Seen in historical perspective, however, a relatively quiet period such as the last eight years is not uncommon. Between 1950 and 1966, for instance, no hurricane or strong storm was registered in Denmark.

As regards the expected future frequency and maximum strength of hurricanes and storms in Denmark, it must be stressed that extreme wind conditions simulated by existing climate models are subject to great uncertainty. Climate experts assess, that there is a trend towards an increased number of storms in Denmark in recent times and a heightened risk that storms will become more frequent and more powerful. This depends on a general intensification of west winds in the northern part of the North Atlantic, which leaves the North Sea – and thereby Denmark – more exposed.

Trends regarding storm surges are influenced by the same factors as hurricanes and storms, and also by expectations of a general sea water level rise due to the warming of the seas and melting of ice, especially in Greenland and Antarctica. The risk of more frequent and more powerful storm surges in the future can therefore give cause for concern, given that the damages from flooding can exceed the damages from forceful winds during hurricanes and storms. As previously mentioned, it is primarily the coastal areas by the Wadden Sea and the west coast of Jutland that suffer from storm surges with extraordinarily high water levels, but these can occur in inner coastal waters too. Against the background of a rising sea level, the national risk profile must therefore also include the possibility of a storm surge hitting Copenhagen, with far greater consequences than seen before in Denmark. Such an incident could arise from a rare meteorological phenomenon where a westerly storm drives water into the Baltic and then, on the back side of the low pressure, turns into an easterly or south-easterly storm, so the water suddenly flows in the opposite direction and gets so dammed up in the southern part of Sound, that the coastal defences around Copenhagen cannot handle the strain. It was storm surges like this that, in 1760, brought about a reported water level 3.5 metres above normal in Copenhagen and, on 13 November 1872, put coastal areas in the whole southern and eastern part of the country under water and killed almost 100 people, primarily on Lolland and Falster. On the other hand, it is of course essential to recognise that the population had no warning back then, that the infrastructure was different, and that the coastal defences were presumably not up to today's standards.

The trends regarding hurricanes, strong storms and storm surges in Denmark will mean that prevention, in the form both of physical measures and influencing peoples' behaviour, become increasingly important with a view to reducing the number of personal injuries and material damage. Such a development occasions changes in, inter alia, building and construction, tree-planting, dimensioning of fire and rescue services, etc.

2.2. Heavy rain and cloudbursts

Characteristics

Episodes of heavy rain and cloudbursts are two of the types of extreme weather, which in recent years have impinged most markedly on Danish citizens, homes, businesses, public institutions and critical infrastructure. In meteorological terms and as a criterion for issuing warnings, the Danish Meteorological Institute (DMI) defines heavy rain as rainfall exceeding 24 mm in six hours locally within the area to which the warning applies. Cloudburst is a term for a brief powerful downpour and is defined as rainfall exceeding 15 mm in 30 minutes locally within a warning area. An alternative insurance-related definition of the term "violent cloudburst", used by the Danish Insurance Association, designates either rainfall of 40-50 mm within 24 hours or 1 mm per minute.

The development of heavy rain and cloudbursts is influenced by many factors in the atmosphere during unstable stratification of warm and cold air masses. When local atmospheric conditions are particularly unstable, cumulonimbus clouds can grow extra large and cause heavy rain and/or cloudbursts – often accompanied by lightning, thunder, strong gusts and hail. The preconditions are most often present in hot weather, and summer is therefore peak season for heavy rain and cloudbursts. The showers mostly build up in the daytime due to the sun's heat, but can also build up at night via significant cooling off in the tops of clouds.

The violent showers that cause cloudbursts are invariably geographically limited phenomena, and cloudbursts are typically highly localised. Some showers stay over a single area, while others drift and spread rain over more and wider areas, but the total extent of land affected is small in comparison with ordinary rain. Moreover, the period of time where the conditions are present is usually brief. Cloudbursts will in particular normally be characterised by an abrupt beginning and end as well as by a rapid and, at times, very large fluctuation in the volume and intensity of rain for brief periods and over short distances. Consequently, it is impossible for meteorologists to predict exactly where, when or with what strength episodes of heavy rain and cloudbursts will occur. A cloudburst warning for the whole of Funen, for instance, does not mean that all of Funen will experience cloudbursts, but that lots of rain will fall in some places and perhaps none in others.

Heavy rain and cloudbursts can occur anywhere in Denmark, but in addition to atmospheric conditions their development is influenced by conditions on the ground. Hence, the DMI indicates that metropolitan areas can be more exposed to heavy rain and cloudbursts than smaller cities and rural areas. This is due to the so-called urban heating effect stemming from, inter alia, asphalt on many roads which, in windless summer weather, can raise temperatures over large cities a few degrees above those in the surrounding countryside.

Heavy rain and cloudbursts cause floods as their primary consequence. Floods are complex processes involving both hydrological and socioeconomic factors. In this connection, a distinction is made between "purely hydrological floods", which occur in uninhabited areas without major social consequences, and "harmful floods", which affect populated areas and/or infrastructure. In the latter case, the consequences depend both on the volume and intensity of the rainfall and on conditions such as:

- The number of citizens, buildings and infrastructure exposed to the risk of flooding.
- Whether the terrain is flat or hilly, so water might quickly gather in forceful streams in lower-lying areas.
- How moist the soil in the affected area is beforehand, which influences the amount of absorbed water versus surface drainage, and how full and water-saturated nearby creeks, streams, wetlands and other natural drains or reservoirs are.
- The density of buildings and the amount of surfaces covered by asphalt, etc., which inhibits seepage.

- The extent and quality of preventive measures, including how effectively sewage systems, overflow basins, drainage areas and other mechanisms transport, slow down or hold back the water masses.
- The acute preventive and operational response by emergency management operators and home-owners to pump water away, clean out gutters and grates, move objects from basements, make urgent repairs, etc. Among other things, fire and rescues services' capacities in the form of large bilge pumps, hoses for removing water, and their prioritising of pumping efforts will impact largely on the consequences' extent.

Possible consequences

Experiences from past incidents in cities, including an extreme cloudburst in Greater Copenhagen on 2 July 2011, show that the direct and indirect consequences of heavy rain and cloudbursts can be far-reaching.

Acute danger of injury can, for instance, arise from traffic accidents due to reduced visibility, aquaplaning, or lack of traffic signals at crossroads in places where floods have caused power outages. Potential dangerous situations can similarly arise if people have to wade through deep water or climb onto installations, e.g. after having had to abandon cars with engine failure on flooded low-lying roads. Other sources of danger can, e.g., be sewage manhole covers thrown up in the air by high pressure from water and compressed air, or sudden scalding steam from district heating and steam pipes, which can burn passersby. The latter phenomenon can occur if rain water enters the heat chambers, and power outage puts the built-in water pumps out of action, whereby the rain water can begin to boil from its contact with hot pipes.

Consequences for life, health and well-being can also arise if emergency management operators come under pressure. Floods can, for example, impede driving conditions for emergency vehicles, and threaten power supplies, emergency power generators, servers and other IT equipment critical to the functioning of alarm and dispatch centres, hospital wards, etc. Experiences also show that fire and rescue services can come under pressure if a considerable proportion of personnel are occupied with responding to alarms from automatic fire detection and alarm systems, which, during floods, are activated far more often than usual.

Experiences further show that heavy rain and cloudbursts can cause anxiety and insecurity among chronically ill persons and patients with oxygen apparatus in their own homes, who are particularly dependent on electricity, or who may need or want to be evacuated because of flooding or power outages.

The risks of infection for people who have been exposed to a mixture of rainwater and sewage can be a serious consequence. Human contact with sewage, which itself may contain disease-producing microorganisms, constitutes a health risk. Moreover, the bacterial infection leptospirosis can be transferred to water when drowned rats are flushed around and out of sewage pipes. The most common symptoms are diarrhoea, a cold and/or sore throat and headache, but leptospirosis can, in rare cases, lead to jaundice and life-threatening effects on the kidneys and lungs. In addition, untreated sewage can be led out into harbour basins, the sea, lakes and watercourses, but the pollution will typically disappear after a few days, since bacteria die quickly in salt water and almost as quickly in fresh water.

Although the possible health consequences should not be underestimated, it is material damage that constitutes by far the greatest risk. According to a survey by the Danish Insurance Association (DIA), one in every seven Danish house owner has suffered damage to the house in the past five years owing to heavy rain or cloudbursts. The extreme cloudburst of 2 July 2011 in Greater Copenhagen was the most costly single incident, with payments calculated altogether at DKK 6.2 billion for over 90,000 claims. For comparison, the DIA estimates compensation in Denmark on account of heavy rain and cloudbursts in previous years (between 1 June and 15 September) at between DKK 135 and 997 million for the years 2006 to 2010. Moreover, the total cost is higher than the sum of insurance payments because the state and many municipalities are fully or partly self-insured. Furthermore, some losses and damages cannot be quantified in economic terms or compensated for, e.g. water or moisture damage to archives, museum exhibits and other cultural heritage.

Finally, heavy rain and cloudbursts can result in considerable challenges to the continuity of critical societal functions. Floods affect the free flow of traffic on the road network and can close roads for days on end. Train services can be disrupted when low-lying tracks, cables, switches, etc. are flooded, and when IT services essential to regulating rail traffic shuts down due to floods or lightning. Roads, tracks and railway embankments can also be undermined and collapse, which creates risk of injuries, prolonged traffic problems and large repair expenses. In the energy sectors, floods and lightning can cause power outages, and flooded steam wells and district heating pipes can cause lack of heating and hot water. In the field of IT and telecommunications, servers, other equipment and connected appliances such as cooling systems, power relays and emergency power generators situated in basements can break down on account of water and moisture damage, short circuits and fires. Telephone exchanges and mobile phone system masts can similarly fail due to flooding or lightning. All functions dependent on affected technology are thus liable also to be affected.

Past occurrences

An extreme cloudburst over Gråsten and surrounding areas in south-eastern Jutland on 20 August 2007 was probably the most powerful brief rainfall incident since a cloudburst near Lønstrup in Vendsyssel on 11 August 1877. Official observations do not offer a thorough account of the Gråsten cloudburst, since the DMI's rain gauges in the area escaped the worst of the rain, but a recently shut down measuring station, which data the DMI considers valid, registered 142 mm rain in approx. 1½ hour at Fiskbæk, two kilometres from Gråsten. A radar estimation indicated 152.6 mm at Fiskbæk and a maximum 10-minute rainfall of 53 mm. These are phenomenal figures in a Danish context, and the DMI has called the incident a "convective bomb" – i.e. a short, extremely powerful and highly localised precipitation incident, in which the vast majority of rain fell on hilly ground contributing to flooding. No people were hurt, but several roads had to be closed and a section of road was washed away near Adsbøl. A railway embankment between Gråsten and Sønderborg was undermined so that tracks were hanging in the air, which could have resulted in a major accident, given that a train had just passed the embankment's weak point before it collapsed. Besides rain, violent wind gusts and hailstones the size of pigeon eggs also caused a great deal of material damage, and about 1,000 strokes of lightning were registered, causing, among other things, power outages and a fire at a farm.

Although the Gråsten cloudburst was the most violent in recent times from a meteorological perspective, its consequences pale in comparison with the cloudburst that hit Greater Copenhagen in the evening of Saturday 2 July 2011. This began with a, meteorologically speaking, unusually explosive formation of thunderclouds over the Sound. In the course of the day, the DMI had updated a cloudburst risk announcement for Zealand, but the upgrading to a genuine warning happened less than 15 minutes before the cloudburst came ashore in a south-westerly direction over Greater Copenhagen. The majority of the rain fell in 1½ to 2 hours, combined with large hailstones and thousands of lightning strokes. Central Copenhagen was hit hardest, with many measurements of over 80 mm, but over 30 mm fell in an area from Lyngby in the north to Taastrup in the west and Greve in the south. 135.4 mm was measured in the Botanical Garden, which is the highest figure registered in Greater Copenhagen for at least 65 years. Rain intensity was measured as 4.5 mm in one minute near the Royal Veterinary and Agricultural University and as 31 mm in 10 minutes and 63 mm in 30 minutes near Ishøj Heating Plant. Such high 1, 10 and 30 minute intensities have never before been officially measured in Denmark, and are reckoned surpassed only by the Gråsten cloudburst of 2007.[2]

[2] Equipment for measuring such intensities became available after 1979 and nationwide use of it began a few years ago.

There were no fatalities while the cloudburst was going on, but, afterwards, five people were reported to be infected with leptospirosis, of which two were hospitalised and one of them died. Furthermore, a survey among 257 people whose jobs had exposed them to rainwater mixed with sewage revealed that 22 pct of them had become sick. Many citizens were also brought into potentially dangerous situations. A few suffered injuries in traffic accidents related to the flooding, and at least nine persons were scalded by boiling hot steam escaping from grates over flooded district heating and steam pipes.

Other serious health hazards arose when traffic conditions impeded passability for ambulances and doctors driving to emergency cases, and floods obstructed operations at several of the Capital Region's hospitals. Conditions were worst at Copenhagen University Hospital, where, among other units, the Trauma Centre and the radiology unit were flooded. The Trauma Centre's reception of badly injured patients had to be temporarily transferred to Herlev Hospital. A short circuit disconnected the hospital's priority power supply for two hours, affecting several intensive care units and a surgery ward, and the emergency power supply functioned only partially. Intensive care patients were moved and the electrical problems were handled, but there had been a risk of a power outage which could have required numerous patients to be evacuated.

Measured in material damages, the cloudburst of 2 July 2011 was the costliest natural incident in Denmark since the hurricane of 1999 and, according to a Swiss reinsurance company, the costliest single incident in Europe in 2011. The damages were due primarily to the effects of water and moisture on homes, businesses and public institutions. From an emergency management point of view, however, it was the widespread breakdown of infrastructure that attracts attention. About 10,000 households suffered power outages (albeit mostly not for more than 12 hours) and about 50,000 district heating customers went without heating and hot water for up to a week. Many of the busiest motorways were closed for 1 to 3 days. Train services were disrupted by flooding of stations, tracks and technical installations; lightning striking electrical equipment; breakdown of IT systems; and a 100-metre long landslide. Some rail lines were closed for days, and a week went by before normal services were resumed. In addition, flooding of a basement with technical equipment at Banedanmark [Rail Net Denmark] threatened to bring trains to a halt on railway lines all over the country.

Other affected societally important IT and telecommunication services included the DMI's super-computer and webpage, the Road Directorate's *trafikken.dk*, the TDC telephone exchange on Blågårdsgade, the Copenhagen Police's phone system, Copenhagen Municipality's emergency call facility for senior citizens, and the prison Vestre Fængsel's computer systems. It is estimated that 70 pct of the City of Copenhagen's cross-cutting and continuity-critical IT systems were close to break-down. The emergency telephone number 1-1-2 worked, but flooding in the technical room of the Alarm Centre for Greater Copenhagen caused failure of parts of the communication equipment and disposition technology and a risk of a full system break-down.

What happened in Gråsten in 2007 and Greater Copenhagen in 2011 constitutes two of the most powerful recent examples, but it should be stressed that heavy rain and cloudbursts occur in urban areas nearly every summer. The latest major example was heavy rain over Aarhus and Anholt on 26 August 2012, when the DMI's measuring stations recorded more than 50 mm rain both places. Other large recent examples include:

- The cloudburst in Metropolitan Copenhagen on 14 August 2010, when 92 mm of rain fell in six hours according to the highest official measurement. Among other roads, this forced the closure of Helsingør Motorway, Holbæk Motorway, Motor Ring 3 and Lyngby Road. When Emdrup Lake overflowed, water masses were so high on a sunken stretch of Lyngby Road that drivers had to abandon their vehicles.
- The cloudburst in Metropolitan Copenhagen on 11 August 2007, which markedly surpassed what the DMI terms a 20-year incident in districts north and west of Copenhagen. In the neighbourhood of

Brøndbyvester, for instance, 62.8 mm fell in one hour, and hundreds of damages occurred in Brøndby, Hvidovre, Herlev, Lyngby and Virum. Three of the busiest main roads were closed, and DEMA pumped water away for five hours at Herlev Hospital to avoid damage to high-tech equipment in the basement.

- Heavy rain over a large area in northern and eastern Zealand on 5 July 2007, causing thousands of flood damages, traffic chaos on roads, cancellation of commuter S-trains due to a landslide, countless call-outs by fire and rescue services, etc. Greve Municipality was hit hardest, partly because this was an exceptionally severe singular incident, partly because rainfall in Greve the previous three weeks equalled the normal half-yearly amount. Aquifers were therefore already full by 5 July and the soil could no longer absorb rain water. Consequently, water ran over fields and through watercourses to form massive floods in many parts of the municipality. In Godsparken, a suburb, residents were offered evacuation on 6 July when water levels reached ½-1 metre. Occupants of 35 out of 78 houses accepted the offer, announced by megaphone and carried out with the Home Guard's four-wheel-drive vehicles and the fire and rescue service's rubber dinghies. The suburb was then guarded until the water was gone, on 8 July.

Possible trends

As an effect of global warming, the water vapour in the atmosphere increases as the temperature rises. Calculations using climate models indicate that the global mean precipitation will increase by around 2 pct and that the number of torrential downpours will increase by around 7 pct for each degree the air temperature rises. Generally, precipitation variations will become more pronounced: rainy areas will receive more rain and dry areas will get drier. Denmark can expect a precipitation increase in winter and more severe precipitation episodes all year round, even though summers are likely to experience less rain on average. The calculations are supported to some extent by official observations of rainfall patterns since 1874, which show a significant rising trend in the number, volume and intensity of heavy rain and cloudburst episodes.

The development will impinge on ecosystems, on urban and rural environments and on infrastructures, and thus creates new demands for the dimensioning of building and construction projects, etc. Danish municipalities have begun a process that will enable them to deal better with water from heavy rain and cloudbursts. This means, inter alia, the drawing up of municipal climate adaptation action plans and concrete measures regarding sewers, water seepage, water collection, and expansion of pump capacity and other preparedness equipment. Likewise, many initiatives in relation to flood warning, flood prevention and flood relief are planned and carried out by state and regional authorities, the business community, academia and voluntary organisations. In many cases, however, these initiatives require considerable time to implement.

Meanwhile, the risk that devastating floods will recur is still there, and the cloudburst over Greater Copenhagen on 2 July 2011 serves as a special reminder of how vulnerable urban areas can be, and how much citizens depend on functioning infrastructure. That cloudburst has been described as above or around the current level for a 100-year event, but the low probability does not mean that a comparable or even worse cloudburst may not strike in the near future. At any rate, less violent but still serious episodes of heavy rain and cloudbursts will affect parts of Greater Copenhagen and other cities in Denmark at regular intervals.

Calculations of future precipitation in Denmark are published on *klimatilpasning.dk*, made available by the Danish Nature Agency's Information Centre for Climate Change Adaptation. The website contains, inter alia, maps drawn up by the DMI on the basis of modelling for three alternative scenarios for the period 2071-2100. Calculations are also shown for a possible scenario fulfilling the EU's objective of a maximum 2 degree global temperature rise by 2100. Finally, calculations for one of the scenarios are applied to the nearer period 2021-2050. The collection of maps is supplemented by tables which show corresponding averages for all of Denmark, and each map expresses a realistic guess on rainfall changes compared with 1961-1990.

2.3. Pandemic influenza

Characteristics

An influenza pandemic is a worldwide epidemic in which a new type of influenza virus causes rapid and continuous transmission of infection throughout large swathes of the population in several parts of the world.

Influenza [flu for short] is a contagious disease due to viral infection in the respiratory tract. In Denmark, the disease is experienced every year as common seasonal flu between November and April, when 5-10 pct of the population typically contracts it. Every 2-3 years on average, an outright flu epidemic occurs, normally lasting 4-6 weeks and typically with around 20 pct of the population infected. Among the infected, most recover after a few days in bed, but the range of serious complications is reflected by noticeable surges in doctors' appointments, hospital admissions, respiratory treatments and deaths. Figures from the State Serum Institute show that over 1,000 additional deaths typically occur in Denmark during a serious flu season and about 1,500 during an average flu epidemic, 90 pct of which are among people aged over 65.

Pandemic flu has historically occurred a few times every century and can, in contrast to seasonal flu and the ordinary flu epidemics, spread globally regardless of seasons. Another characteristic of flu pandemics is that they can occur in two or three waves, the second of which can be substantially worse than the first. However, the length of the intervals between pandemics does not follow any definite pattern and the geographical spread, the infection rate, the mortality rate, and the worst affected age and patient groups varies.

Consequently, the term "pandemic" refers only to the global spread of infection from a new virus, and does not in itself say anything about the number of life-threatening cases of illness or deaths resulting from it. Irrespective of how many or how few people fall seriously ill or die, the proportion that becomes infected during a pandemic will always be greater. The derived consequences can be felt outside the health sector and potentially disrupt continuation of critical societal functions for shorter or longer periods because of staff absences. That is why, in most countries, pandemics are considered one of the largest and enduring risks.

The explanation for seasonal flu and recurrent epidemics is that the different types of flu virus circulating among humans are in a state of constant genetic change.[3] This phenomenon is called "drift". Pandemics are typically caused by the less common "shifts", which alone apply to Type A flu virus, whereby entirely new subtypes are generated. In these cases, the spread of infection is not impeded by antibodies and the degree of immunity residing in the population from earlier viral infections or from vaccinations. In a "shift", the virus' disease-causing properties can also change. In addition to "shifts", pandemics can also originate from more gradual processes known as "adaptive mutation". For example, a pandemic can occur when genetic material from two or more Influenza A subtypes in animals and humans mix and mutate into a new subtype, which develops from being able to migrate from animals to humans into also being able to easily transmit infection between humans. Pigs, for instance, can become a source ("mixing vessel") for a pandemic virus, since pigs can simultaneously be infected with viruses circulating among pigs, birds and humans.

During a pandemic with a new virus, people become infected in the same way as in the case of normal flu. The virus spreads primarily via close human contact. This happens partly by means of airborne drops dis-

[3] There are three overall types of flu virus: A, B and C. Type A is found in nature, especially among swimming and wading birds, and has three subtypes (H1N1, H2N2 and H3N2), which infect humans and can cause epidemics and pandemics. Type B is found only among humans and can cause local outbreaks – in Denmark most frequently when incidence of Type A is falling off. Type C is also only found among humans, but merely leads to less serious, sporadic cases of illness.

charged when sneezing, coughing or speaking, partly by means of direct or indirect touching, when someone whose hands have picked up virus touches his/her nose, eyes or mouth, whereby virus enters the body.

Possible consequences

A pandemic can cause direct consequences for life, health and well-being on the one hand, and, on the other, indirect consequences in the form of socio-economic losses and a strain on the continuance of many of the activities basic to society's ability to function.

The health consequences for infected individuals can vary from mild symptoms to complicated courses of illness involving pneumonia, circulatory collapse and death. A case of the flu typically lasts for less than a week, followed by 1-2 weeks of coughing, tiredness and lowered physical ability. But illness can become more protracted and serious if the viral infection directly attacks the lungs or leads to a bacterial infection. The most serious accompanying disease is bacterial pneumonia. The strain on the lungs and heart can be critical especially for the elderly, the obese, sufferers of lung disease, arteriosclerosis and diabetes, and women in the final stage of pregnancy.

The health consequences at the national level cannot be estimated in advance. Past pandemics have taken very varied courses, making it impossible to predict neither the infection rate nor the number of serious cases, the excess mortality, or which age and patient groups will be hardest hit. However, a worrying risk witnessed in past pandemics can be that otherwise healthy young people and adults can be infected in larger numbers and fall more seriously ill than in the case of ordinary flu. Furthermore, after circulating for a certain length of time, a pandemic virus can change its properties and become more dangerous. In addition to disease, a pandemic can also breed anxiety and insecurity, and thus consequences regardless of whether individuals are infected or not.

A serious pandemic will first and foremost be capable of putting the entire health sector under considerable pressure due to the expected steep rise in the number of doctors' consultations, home visits, hospital admissions, intensive care cases, etc. A large number of infected people experiencing genuine complications will need treatment, and even more people can be expected to seek medical assistance because they believe they have contracted serious accompanying diseases. At the same time, medical personnel themselves risk being infected, whereby the health sector's capacity is further reduced.

Outside the health sector, a serious pandemic can likewise disrupt the normal continuation of a whole range of critical societal functions for longer or shorter periods. Throughout society, large challenges may arise on account of the expected increase in the daily average number of absentees from all workplaces. These absences will occur partly because many employees become ill, partly because many will choose to remain at home due to the danger of infection. Furthermore, many will have to look after children or other family members, either because of illness or because schools and day care centres close. Yet more absences from work may be caused by cancellations and delays of public transport due to personnel off sick. The absences may especially affect workplaces which are staff-intensive, have a high degree of contact with the public, or depend particularly on employee groups and key individuals whom it is hard to find substitutes for.

The staff absence has the potential to impinge on the standards of service offered within critical societal functions such as the police's enforcement of law and order, fire and rescue services, prehospital emergency services, hospital operations, etc. Energy supply security, IT and telecommunication services, etc. may also eventually be weakened, if the absence of key personnel limits the ability to carry out repair work, restorations after breakdowns, etc. Another possible consequence is that public services such as refuse collection or postal delivery may stop or become irregular. Meanwhile, the practice of hoarding in response to the danger of infection may result in shortages of certain medicines and personal protective equipment.

The socio-economic consequences can be far-reaching. Industry may suffer from reduced productivity, which will affect levels of costs and earnings. Deliveries to factories and customers may be held up by reduced freight capacity. Likewise, there may be indirect consequences for sales and social services if businesses and public institutions reduce contact with customers and clients on account of infection risk. The number of travellers may fall considerably and thus increase the consequences for international trade and tourism.

Past occurrences

Stories of violent and extensive outbreaks of flu-like illnesses go back to the 16th century, but it was not until the end of the 19th century that pandemics could be documented through biological examinations. On this background, it is assessed that 3-4 pandemics have hitherto occurred per century.

In the past 100 years there have been four pandemics: Spanish flu in 1918-19 (caused by the A (H1N1) virus), Asian flu in 1957-58 (A (H2N2)), Hong Kong flu in 1968-70 (A (H3N2)) and, lastly, New influenza A (H1N1) in 2009-10. Aside from these, several episodes during the past decades have raised concern about possible pandemics, primarily Russian influenza A (H1N1) in 1977-78, the very serious flu-like lung disease SARS (Severe Acute Respiratory Syndrome) in 2002-03, and a series of outbreaks of avian influenza A (H5N1), starting in 1997 with infections transmitted from birds to humans and risk of mutation into a new virus easily transferable between humans.

The Spanish flu of 1918-19 was the disaster against which all pandemic risks are compared today. It is believed that up to half the world's population was infected and that between 20 and 40 million people died. No other event in history has caused so many deaths in such a short timeframe. The pandemic occurred in three waves (early spring 1918, autumn 1918 and late winter 1919), with the second wave being the worst. The reasons for this remain uncertain, but may have been linked to the transporting of vast numbers of people over great distances at the end of World War 1. Other exceptional aspects of the Spanish flu were that it struck the young and the relatively young adults particularly hard and that it killed very fast. A proportion of those infected, who did not die of the virus within a few days, died of accompanying bacterial diseases, chiefly pneumonia, which was hard to treat at that time since antibiotics had not yet been developed. About 80 pct of those who died were aged between 15 and 45. In Denmark, over 14,000 people are thought to have died. In terms of the present population, the equivalent would be some 26,000 flu-related deaths.

The two subsequent 20th-century pandemics were far milder than the Spanish flu. Despite high infection rates, the estimated number of deaths worldwide came to "only" 2 million for the Asian flu in 1957-58 and 1 million for the Hong Kong flu in 1968-70. In Denmark, about 1,700 and 1,300 people respectively died during these two pandemics, which was not markedly different from the death toll during normal flu epidemics.

In 2009, the new influenza type A (H1N1) brought about the first pandemic of the 21st century. The pandemic was initially called "Swine flu" because the virus originated among pigs before spreading to humans. In April 2009, the first case of human-to-human infection was reported in Mexico. Soon after, other cases were registered in the US, and within a few weeks the infection spread over most of the world. When the World Health Organisation (WHO) declared a regular pandemic (Pandemic phase 6) on 11 June 2009, 74 countries had reported laboratory-confirmed cases of infection. By the end of the year, cases were registered in nearly all countries.

Despite the rapid spread of infection, it gradually became clear that this pandemic was a mild one. There were deaths, but the great majority of those infected did not experience particularly serious symptoms. The pandemic chiefly affected persons aged 5-24. Additionally, people within certain at-risk groups suffered more serious courses of illness, just like during seasonal flu and ordinary flu epidemics. There are still no accurate figures for the infection rate and A (H1N1)-related deaths worldwide, but studies indicate that 20-40 pct of the population in certain areas became infected. On 10 August 2010, the WHO declared that the pandemic was over, so that the world moved into a post-pandemic period. The pandemic A (H1N1) virus now seems to behave like a normal seasonal flu virus.

In Denmark, a small peak in the number of A (H1N1) flu patients was observed in the second half of July 2009. After this, the number rose in October and November and reached its chief peak in week 47 before falling steeply for the rest of the year. By mid-December 2009, 4,642 confirmed A (H1N1) cases and 21 A (H1N1)-related deaths were registered in Denmark, of which three of the dead were outside any at-risk groups. The figure later rose to 30 laboratory-confirmed deaths. The mortality rate was thus much lower than for annual seasonal flu and the ordinary flu epidemics. The infection rate in Denmark is estimated to have been no higher than 7-10 pct.

Notwithstanding the relatively limited consequences for health, the handling of the pandemic required prolonged and extensive crisis management by the Danish authorities. In their communication to the population at large and to medical personnel, the authorities had to take into account, that knowledge about the new virus was insufficient initially and that different instructions had to be communicated to different sections of the population. The response also involved a major effort to indentify population groups for vaccination, including people in at-risk groups, medical personnel who are massively exposed to virus transmission or treating the critically ill, and various personnel working with critical societal functions.

Possible trends

A new pandemic will certainly occur, but nobody can say when, what virus will cause it, how serious it will be, which sections of the population will be at greatest risk of serious illness and death, and which means will prove most effective in combating the pandemic nationally and internationally.

Statistically speaking, the next pandemic can be expected within 10 to 40 years. It seems most likely, that the next pandemic will be relatively mild, like those in 1957-58, 1968-70 or 2009-2010, but it is possible, that a severe pandemic occurs, which in terms of the infection rate (albeit hardly the death rate) can approach the Spanish flu of 1918-19. The health consequences of a similarly aggressive virus will probably be lesser in modern times than those experienced at the beginning of the last century due to, inter alia, a better organised health sector, better treatment options, better hygienic conditions, and a generally better standard of health among the population.

On the other hand, a virus that infects easily and rapidly can spread all the quicker from one country to another and from one continent to another given the mobility in the modern world. As described above, a sufficiently widespread infection rate could – even if the infection itself only causes mild-to-moderate illness – trigger so much absence from workplaces, that it might jeopardise the continuation of normal and critical societal functions. For this reason alone, pandemic flu can at any given time be expected to have a prominent position in the national risk profile.

2.4. Animal diseases and zoonoses

Characteristics

Production of livestock and foodstuffs can be affected by outbreaks of a variety of serious infectious animal diseases. Some animal diseases are confined to a single species, while others can spread between species. When the number of new cases rises rapidly, it is called an epidemic or epizootic development. In certain cases, the diseases can also spread between animals and humans, and these are called zoonoses. A zoonosis that causes illness in humans does not necessarily do so in animals, since animals may merely be carriers of infection. Certain zoonoses, however, may cause serious symptoms in both animals and humans.

The spread of animal diseases and zoonoses within and between countries is combated for the sake of animal welfare, to prevent infection among humans, and to maintain societally important agriculture and food industry. Healthy animals are a precondition for a large production and export of livestock and foodstuffs, and extensive outbreaks of animal disease can, at worst, have grave consequences for the Danish economy.

The monitoring and combating of a range of serious diseases among livestock and wild animals take place according to international regulations and guidelines established by the EU and the World Organisation for Animal Health (OIE). The regulations are embodied in Danish legislation and adapted to Danish conditions. Once a disease breaks out, control measures are put in place to fight it and stop the spread of infection at all stages of food production from field to table. This may include the culling of infected livestock, a ban on transporting animals and foodstuffs in parts or the whole of the country, requirements for increased protection against infection on farms and in food-processing factories, and vaccination of animals.

The diseases seen as the potentially greatest risks from the standpoint of Danish veterinary preparedness are classic swine fever, African swine fever, foot-and-mouth disease and avian influenza. These are traditional and exotic diseases, recurrent and widespread in a number of countries and considered to represent permanent risks. Beyond this, it is reckoned that climate change and globalisation may contribute to the probability that the risk of introduction of new diseases in Danish livestock will increase in coming years.

Classic swine fever is caused by a virus and infects between animals of the pig family, including wild boars. The infection is transferred from animal to animal through direct contact or indirect contact by means of e.g. straw bedding, feed and water contaminated by urine, dung or rhinorrhoea from sick animals. Infection can also be spread through feeding with unboiled meat containing the virus, e.g. meat waste or offal. The infection cannot be transmitted to humans. Classic swine fever occurs in two forms. The more serious form takes a rapid course with violent symptoms, such as high fever and a high mortality rate. The other form is milder and more prolonged, with a low mortality rate among mature animals. Classic swine fever used to be known as European swine fever to distinguish it from African swine fever. The African version has a longer incubation period, but a similar course and almost identical symptoms, ending in death in over 90 pct of all cases.

Foot-and-mouth disease is caused by a virus which can infect all kinds of cattle, pigs, sheep, goats and other cloven-footed animals. Foot-and-mouth is extremely contagious and therefore one of the most serious animal diseases in existence. Infected animals (especially pigs) exhale large quantities of virus, and virus is passed on in all excretions and secretions such as saliva, milk, semen, dung and urine. The infection can spread directly from one animal to another, but it can also spread indirectly, e.g. via lorries taking milk to dairies, mother animals suckling their young, use of semen from infected bulls for artificial insemination, and winds can carry the virus over great distances. Wild animals can transmit the infection to livestock, and humans who have come into contact with infected animals can transmit the virus by way of their clothing, their skin or their breathing. Among cattle, the symptoms can include slobbering at the mouth and sores or blisters on the tongue, in the oral cavity, in the hoof cleft or on the udder. Pigs can, in addition to sores and blisters, suffer pain in movement and sudden paralysis. Among sheep, goats and deer, the symptoms are typically milder. Foot-and-mouth is normally not fatal, but infected animals never fully recover.

Avian flu is a viral disease that mostly attacks birds and can kill up to 100 pct of a stock of poultry. The disease is due to infection with influenza A virus and can be divided into two types: high pathogenic avian flu, which has strong symptoms, and low pathogenic avian flu, which has mild symptoms but is able to change into the high pathogenic type. Infected birds give off the virus through secretions from the respiratory tract and through faeces. The infection is spread by direct contact between birds or indirectly, e.g. via infected feed, drinking water or appliances. Wild birds are a permanent source of the infection, and birds of passage in particular can spread it over great distances. Symptoms differ widely among different kinds of bird species. Chickens and turkeys develop apparent and wide-ranging symptoms, whereas swimming birds are more resistant. The classic symptoms are a sudden high mortality rate, a drastic fall in or cessation of egg-laying and respiratory infection, together with inflammation of, weeping from, and swelling around the eyes. Early symptoms may be loss of appetite, reduced desire to drink, and a slight rise in the mortality rate. The disease may also run a more rapid course, in which many birds suddenly die without or with minimal signs of illness. Avian flu can infect humans and other species and so belongs to the category of zoonoses.

Possible consequences

The health consequences for infected animals can range from mild symptoms to extensive mortality. Even animal diseases that do not directly cause death can result in permanent harm to the animals and a risk of further spreading, and therefore necessitate the full or partial culling of livestock.

In the case of zoonoses, there are consequences for humans as well. In Denmark, most zoonoses, such as salmonella in poultry, pigs or cattle, are spread through the ingestion of infected foodstuffs, typically leading to infections of the gastro-intestinal tract. In rare cases, zoonoses can be fatal to humans.

In addition to health consequences for animals and humans, outbreaks of certain animal diseases can have wide-ranging economic consequences for agriculture and other occupations involving production and export of livestock and foodstuffs. These economic consequences may take the form partly of production losses; partly of expenses related to diagnosis, treatment, decontamination, temporary restrictions on transport and sales, and other measures aimed at containing the outbreak; and partly as the result of lowered confidence in the safety of animal breeding and food production in Denmark and abroad. In Denmark, the agricultural and food production industry employs around 175,000 people and accounts for some 14 pct of total national exports of goods. In 2010, for instance, Denmark exported agricultural and agroindustrial products to the value of DKK 110 billion, whereas total imports of agricultural products had a value of DKK 28.8 billion.

The direct costs of fighting animal diseases can be marginal in comparison with the commercial costs. For example, estimates based on simulated outbreaks of foot-and-mouth disease, such as can occur in Denmark within the foreseeable future, show loss of exports that are about 10 times larger than the cost of fighting the disease via any of the examined strategies. The estimates show that the total economic loss per foot-and-mouth epidemic would average DKK 4-5 billion, but there are possible wide variations of DKK 3-8.5 billion. The greater part of the export loss is triggered already by the first case of foot-and-mouth, which therefore assumes even greater economic significance than the extent and duration of the epidemic.

Past occurrences

Classic swine fever has not been recorded in Denmark since 1933, but outbreaks have for many years been an extensive problem in large parts of Europe, occurring both among pigs and wild boars. For example, outbreaks of classic swine fever in Holland in 1997 led to the culling of 10.3 million animals and to estimated payments of EUR 1.5 billion in compensation. In countries with a wild boar population, the infection has spread from wild boars to pigs. This happened in 2001-2005 in Slovakia, Germany, Luxembourg and France, among other countries. The latest classic swine fever outbreaks have been in, inter alia, Lithuania in 2011 and Latvia in 2012, where disease was detected in pigs and wild boars. In Denmark, several suspected outbreaks have been registered in recent years, but these could all be rebutted following closer examination.

African swine fever has never been detected in Denmark. In 2007, it was registered in Georgia and Armenia for the first time. Since then, it has spread to Ukraine and Russia, among other countries. In Russia, it has spread steadily throughout 2012 and is now approaching the frontiers of the Baltic countries, Finland and Norway. Previously, African swine fever has also been detected in several countries of southern Europe.

Foot-and-mouth disease occurs sporadically in a number of European countries. It occurred frequently in Denmark during the 1960s, but the number of outbreaks since then has been limited, and the most recent took place back in 1983 in a consignment of cattle that had been shipped from southern Funen to Zealand. This outbreak was the last in a wider epizootic that originated in Ukraine and spread through East Germany. The last particularly serious outbreak close to Denmark took place in the UK in 2001, when over 2,000 farms were affected. The 2001 outbreak spread to Ireland, France and the Netherlands. Countermeasures included the culling of approx. 6.2 million animals in infected herds and trade restrictions inside the EU, with heavy economic losses for animal and foodstuffs producers as well as indirect consequences for the environment and tourism in affected areas. In Denmark, there were cases of suspected foot-and-mouth in 2001, which were all disproved. Nonetheless, Denmark too felt the effects of the lengthy ban which several countries imposed on meat imports from the EU. The UK experienced several foot-and-mouth outbreaks again in 2007, on account of a spillage of vaccine virus from a vaccine producing factory in southern England. In 2011, Bulgaria suffered 11 outbreaks of foot-and-mouth among tame animals and one in wild boars. Those outbreaks were in the south-east of the country bordering Turkey, where foot-and-mouth is endemic.

The last outbreak of avian flu in Denmark happened in 2006, when 44 cases across the country were confirmed from March to May. Only six cases were found among poultry, while the rest occurred among wild birds. The virus was of the particularly disease-producing type H5N1, and had in 2005 spread from Asia to Russia and further westwards to the Black Sea region and Europe as part of the world's biggest H5N1 outbreak among birds to date. In Denmark, the outbreak led to a whole series of anti-infective measures and restrictions, e.g. segregation of different species of poultry, feeding of poultry under roofs, quarantine zones for the transportation of poultry, and a comprehensive emergency management response to collect and examine dead birds, keep the public informed about risks, purchasing antiviral medicines for protection of vulnerable population groups, etc. The outbreak is reckoned to have cost the Danish poultry trade about DKK 330 million in lost export orders. At a global level, it aroused concern that H5N1 would mutate into a new virus that could be directly and quickly passed on among humans and, in the worst instance, cause a pandemic (cf. section 2.3). However, there is substantial evidence that H5N1 will not give rise to the next pandemic. Millions of people have presumably been in close contact with H5N1-infected birds during the past decade, yet "only" a few hundred have fallen seriously ill or died from avian flu worldwide, and the great majority of these cases were outside the EU.

In addition to the diseases mentioned above, the last years – probably with climate change as a contributory factor – have seen the introduction of animal diseases which were unknown in Denmark 10-15 years ago. Bluetongue, which for many years was described as a vector-borne disease confined to Europe south of latitude 50, was diagnosed in Denmark in 2007. In 2008, 15 outbreaks were identified, which set in motion a vaccination programme covering Lolland, Falster, Zealand, Funen and large parts of Jutland. This disease, which attacks sheep and cattle, is carried by stinging insects and biting midges. A study of the presence of midges of the culicoides genus in the course of monitoring programmes in 2007-2010 has demonstrated that Denmark is generally free of infection in the period December to April/May. There is no certain knowledge regarding how the virus can survive the winter. Denmark was declared free of bluetongue in January 2011. Another vector-borne disease is Schmallenberg virus infection, which causes deformed and still-born off-spring in sheep, goats and cattle. This disease was discovered in northern European countries in 2011 and diagnosed in Denmark in 2012. Neither bluetongue nor Schmallenberg virus can cause disease in humans.

Finally, bovine spongiform encephalitis (BSE) – aka mad cow disease – stands out as a disease that no longer constitutes a major risk, and in time is expected eliminated, but which during the 1990s and 2000s illustrated the huge consequences a cross border zoonosis can have. BSE is a deadly brain disease in cattle, which began to spread in the UK through the use of meat-and-bone meal made from dead animals as feed, and which infected humans as a variant of Creutzfeldt-Jakob disease (vCJD) through ingestion of infected meat products. The diffusion of the disease reached its climax in the 1990s, and altogether some 4.4 million head of cattle were culled in the course of a British eradication programme. Meanwhile, however, the infection had spread to other countries through exports of live animals and meat-and-bone meal. An increasing death toll of vCJD undermined consumer confidence and brought about an EU embargo on import of British beef from 1996 to 2006. The most important measure against BSE is a ban on using possibly infected proteinaceous feed for ruminants (cattle, sheep and goats). In practice, that means meat-and-bone meal made from ruminants. This was banned from ruminants' feed in 1990, but, since contamination of cattle feed from other types of feed easily occur, it became evident over the years that the ban had to be extended to all animal species and all types of feed. Hence, the EU in 2001 widened the ban to include all kinds of animal protein in feed for nearly all production livestock. The BSE crisis is estimated to have cost the UK billions of pounds. Over 200 humans, mostly in the UK, are confirmed or presumed to have died from vCJD, but the number of cases has fallen steeply since 2000. A total of 18 BSE cases have been found in Danish-born cattle, including three cases in exported animals. The last case occurred in 2009, but all 18 animals were born before the EU ban came into force. Thanks to the EU ban, other restrictions and comprehensive checks on slaughtered animals, Denmark is today regarded as a country where the risk of BSE is negligible.

Possible trends

Outbreaks of animal diseases in a number of countries with highly industrialised agriculture in the last few decades have shown how vulnerable the agricultural sector can be when faced with well-known diseases like classic swine fever, foot-and-mouth disease and avian flu.

Both in Denmark and in the rest of Europe, better organised inspections, preventative measures and eradication programmes have contributed to limiting outbreaks and the spread of infection. The EU's ban on meat-and-bone meal in feed for production livestock is an example of a ban which has had a particularly beneficial effect. Close cooperation between responsible public authorities and the agriculture and food industry is likewise an important factor in combating the spread of disease. One example of this is the Danish campaign for vaccination against bluetongue in 2008-2010 carried out jointly by the authorities and industry.

On the other hand, there are factors at work which may increase the likelihood of more numerous and more extensive disease outbreaks. The international trade in animals and animal products is rising. In the same way, tourism and the growing tendency to take household pets across national borders add to the risk. Agriculture now involves, inter alia*,* more transportation of live animals and over longer distances, at a greater risk of spreading infection. On a global level too, increase in trade and commercial intercourse together with the rise in livestock and food production to meet the demands of the growing population, contribute to a heightened risk that infectious animal diseases may spread across national borders.

Finally, global warming is also expected gradually to increase the risk of outbreaks of animal diseases and zoonoses, since one of the possible effects of climate change is to influence the geographical distribution of primarily wild animals and insects that carry infection. Climate change means the introduction of new infectious diseases and their spreading among animals and humans. Rising temperatures may alter the conditions for the occurrence of diseases that at present are viewed as exotic in Denmark. As examples, vector-borne diseases are especially noteworthy, since slight rises in e.g. temperature and moisture can allow ticks and mosquitoes to settle in new places and breed in explosive numbers during the summer season. On this basis, insects can spend part of the year fostering and spreading exotic viral diseases to animals and humans.

2.5. Transport accidents

Characteristics

The term "transport accidents" here applies to accidents with any means of transport involving physical transport of people or goods as well as to accidents related to transport infrastructure and its administration.

The immediate cause of transport accidents is typically unintentional human actions, technical faults or a combination of both. However, transport accidents can also be the indirect result of various weather phenomena or intentional actions like vandalism or terrorism (c.f., inter alia, sections 2.1., 2.2 and 2.9).

Transport accidents in the aviation sector can occur on board aeroplanes and other aircraft in the air or on take-off and landing runways at airports. The potentially greatest risks relate to crashes of large passenger planes. Plane crashes occur mainly at take-off or on landing, but can also occur in mid-flight, e.g. through collision between two planes or as a result of engine failure, erroneous navigation or other technical or human errors. Planes usually carry large fuel supplies, adding to the risk of fire or explosion in the event of collision. If a plane crashes on land, the victims will not necessarily be limited to the passengers and crew, since pieces of wreckage can kill or injure people on the ground and cause great damage to buildings, etc.

Transport accidents in the maritime sector can occur at sea or in harbours. The potentially greatest risks relate to cruise ships, passenger ferries and other large vessels with many people on board. The primary types of accidents are capsizing, shipwrecking and fires. Among other causes, a ship may capsize or wreck by running aground or colliding with another ship, a fixed bridge or an offshore platform. A conflagration can entail a particular risk, as people on board have fewer chances of escaping from fire, heat, smoke and flue gases. Depending on the ship's cargo or, if fire reaches fuel-tanks, there may also be a danger of explosion.

Transport accidents in the land transport sectors can occur on railways, on roads, and on or in related infrastructure such as bridges, tunnels, stations, stopping-places, freight terminals, etc. The potentially greatest risks relate to the railway sector, and especially to disasters involving passenger trains (S-trains, regional trains, long-distance trains and the Metro). Collisions of trains on the same track or exchanging tracks can happen if a traffic manager makes a mistake or a driver absent-mindedly passes a red signal. Moreover, damaged tracks or safety systems can cause derailment, either on an open section or at a place where trains may collide with other trains, buildings, bridges or other infrastructure. In such accidents, the victims will not necessarily be limited to the passengers and train staff, but may include people in the immediate vicinity. A collision of a train and a road vehicle at a level crossing is usually worse for the latter, but, depending on the train's speed and the vehicle's weight, a collision may at worst derail and overturn the train.

In the road sector, accidents can occur through collisions between buses, trucks, cars, etc. and in connection with road works. Traffic accidents on the roads are frequent, but also the least important type of transport accident in relation to the national risk profile, since, taken singly, they seldom involve more than a few people killed or injured. In some cases, however, the consequences can be larger, e.g. accidents with busses carrying many passengers or motorway pile-ups, especially if they happen in tunnels or on bridges.

Accidents in tunnels and on bridges, whether on roads or railways, can constitute a special risk, since tunnels and bridges form traffic bottlenecks in which a single accident entails danger of further collisions. If an accident in a tunnel results in an outbreak of fire, the situation can become particularly dangerous; partly because the shape of the tunnel allows fire, heat, smoke and flue gases to spread with greater ease and rapidity (the chimney effect); partly because the people held up in the tunnel have fewer chances of escape. On bridges, those involved in an accident similarly have fewer chances of escape than on open stretches.

If a ship sails off course and collides with a bridge, there may be great danger to people on board the ship and also, under certain circumstances, to people in cars and/or trains on the bridge. The risk depends, inter alia, on the bridge's construction and the ship's dead weight, height and speed at the moment of collision. A possible but less likely disaster scenario could, for instance, arise if a very heavy ship sails off course and its bow rams directly into a bridge pier. At worst, this might cause the pier to slide out from its base while the bridge's superstructure is pushed away from its bedding, so that bridge spans with sections of road and/or railway crashes down. Similarly, great damage might be done to the bridge and to people in cars and/or trains on the bridge if a tall, heavy ship sails off course and hits a bridge span directly. For the Great Belt fixed link, the risk of a ship colliding with a bridge pier or bridge span chiefly concerns the West Bridge. The shipping lane under the West Bridge is over 20 metres deep, so even the biggest ships sailing off course would not run aground prior to a collision, and the bridge is a low one with an 18 metre main passage height and less near the coasts on either side. The West Bridge is constructed to withstand the impact of a ship with deadweight of 2,000 tonnes travelling at a speed of 14 knots. Through passage is therefore allowed only to ships with deadweight of less than 1,000 tonnes. All other ships must pass under the East Bridge.

Possible consequences

When mass transport of people takes place, an accident can cause a large number of killed and injured. Planes, ships and trains can transport more people than cars or buses, and thus also more potential victims. During the initial phase of emergency response to complicated transport accidents, there will often be uncertainty as to the numbers of presumed dead, injured and missing persons – if, for instance, the scene of accident is extensive and contains numerous pieces of wreckage and potentially many trapped persons. Furthermore, the accident scene can be fraught with dangers for rescue workers. As with all major accidents, there may also be serious psychological consequences for both survivors and next-of-kin.

Major transport accidents can also cause wide-ranging material damage, partly to the means of transport involved, partly to surrounding infrastructure and buildings, which may be hit by the means of transport in question or by fragments of it, e.g. in the case of plane crashes or train derailments and collisions. Repairs and cleanup after transport accidents can thus be a matter of great expense. If the damage necessitates prolonged traffic diversion or alternative transport arrangements, this typically also entails significant costs.

Besides deaths, injuries and material damage, transport accidents can bring about environmental consequences in the form of pollution. Transport accidents involving spillage of dangerous substances can have grave consequences for life, health, property and the environment. However, the topic of transport accidents with dangerous substances are not dealt with in this section, but are covered in section 2.6 regarding accidents with dangerous substances on land, and in section 2.7 regarding marine pollution accidents.

Finally, derived large-scale consequences for the maintenance of critical societal functions can ensue if a major transport accident forces the prolonged closure of an airport, seaport, shipping route, bridge, tunnel, station or important section of railway or motorway. For instance, a discontinuation of road and rail traffic through the bridge and tunnel links across the Great Belt or The Sound would affect large sections of the population and business alike, and take on an international dimension through its negative influence on transport between the rest of Scandinavia and the continent. The effects could be similar if a major air disaster temporarily caused the closure of Copenhagen Airport, which is Scandinavia's largest air traffic hub. Public transport in the Metropolitan Area would be correspondingly hard hit if, for instance, an accident were to close Copenhagen Central Station or Nørreport Station for a lengthy period.

Past occurrences

Fatal air accidents are rare in Denmark, and most happen to small privately owned planes. However, there have been a few major fatal accidents with airliners. The most recent and worst happened on 8 September 1989, when a Norwegian charter plane en route to Hamburg crashed in Skagerrak 18 km north of Hirtshals and all 55 people on board died. The second worst accident was on 28 August 1971, when a Hungarian airline Malév plane en route to Budapest crashed shortly before a stopover at Copenhagen Airport, with 31 dead and only three survivors. Beyond this, there were six fatal air accidents over Danish territory in the period 1946-1960, each of which caused between eight and 28 deaths. In more recent decades, there have been no fatal accidents with airliners in Denmark. There have, however, been a few accidents that could have cost lives, e.g. on 9 September 2007, when a SAS Dash8 crash-landed at Aalborg Airport because of a defective undercarriage, whereupon an engine caught fire and a propeller blade sliced through the cabin.

On the subject of airline traffic involving Danish commercial interests, the worst air accident in the history of SAS occurred on 8 October 2001 at Linate Airport, outside Milan. As an SAS airliner was starting up, a small German-registered Cessna plane drove into its side, causing it to skid into a baggage area. All 110 people on board the SAS airliner, including 16 Danish passengers and two Danish crew members, together with four people in the Cessna plane and four people in the baggage area, were killed.

The biggest passenger ferry accident near Denmark in recent times, and one in which a large number of Danish citizens were involved, happened on the night of 7 April 1990, when fire broke out on the Danish-owned M/S Scandinavian Star. This caused 159 deaths among the 482 passengers and crew members. The ferry was travelling from Oslo to Frederikshavn and was off Lysekil in Sweden when the accident occurred. In Danish waters, on the other hand, there have been no major fatal accidents involving ferries or other passenger ships since 8 July 1959, when 57 people died following an explosion and fire on the tour boat Turisten on Haderslev Pond. Some died in the flames, but most drowned in low water after jumping overboard. There were 93 passengers on board although the boat was permitted to take only 35, which contributed to the outbreak of panic. In the same year, on 30 January 1959, the ship M/S Hans Hedtoft was lost on the way from Greenland to Copenhagen after colliding with an iceberg, whereby all 95 people on board died.

The worst railway accident in Denmark's history occurred on 1 November 1919 at Vigerslev, where a train from Korsør ran into a train from Kalundborg at a standstill after a mistake with a manually operated block system. The rear five coaches of the Kalundborg train tumbled eight metres down the railway embankment, followed by the Korsør train's locomotive, which smashed into the coaches. In all, 40 people died and 58 were seriously injured. In more recent times, Denmark has been spared railway accidents of such magnitude. A calculation shows that there have been 12 fatal train accidents in the last three decades, comprising three minor collisions between trains and cars or other vehicles on level crossings with 1-2 deaths, and nine derailments and/or collisions of trains with 1-8 deaths. The worst of these happened on 25 April 1988 outside Sorø, when an inter-city train came off the rails and overturned because of too high speed, killing eight people and injuring 72. The second worst was on 2 March 2000 near Kølkær, when two regional trains collided head-on at high speed after a driver had overlooked a stop signal. It was considered a miracle that only three were killed and 39 injured, given extensive material damage with coaches twisted out of shape.[4]

[4] The other seven fatal accidents in the last 30 years were: a collision of an S-train and another, derailed S-train at Holte in 2002 (one dead and five injured); a collision of two trains between Firhøj and Søborg in 1997 (two dead and three injured); a collision of a derailed flatbed truck and a passenger train at Næstved Station in 1993 (two dead and five injured); a derailment of an inter-city train at Roskilde Station in 1992 (one dead and two injured); a collision of two S-trains at Dybbølsbro Station in 1992 (one dead and 70 injured); the collapse of a goods train unto a road near Hvidovre Station in 1986 (one dead); and a collision of a passenger train and a stock train near Stenløse in 1983 (three dead and 22 injured). There have also been several accidents where no one died, but which caused injuries and/or major damage.

On Denmark's road network, there have similarly been no very large-scale fatal transport accidents in recent years. In February 2001, a double-decker bus crashed into Knippels Bridge in Copenhagen because the driver overlooked warning signs regarding the bridge's clearance height and exceeded the speed limit, so that the roof of the upper deck of the bus was peeled off. This accident resulted in two dead and 10 seriously injured. A smaller accident took place outside Hørsholm in January 2012, when a bus carrying schoolchildren collided with a car. This caused one death and five cases of serious injury.

Possible trends

Generally, a rise in both the volume and the intensity of land, sea and air traffic can be witnessed, which, other things being equal, increases the risk of major transport accidents in Denmark. On the other hand, this risk is also affected by the continuous implementation of measures to improve safety within the various transport sectors.

Internationally, air traffic has increased by about 50 pct over the last 10 years, but the same period has seen a marked reduction in the number of air accidents, partly because of international standardising of regulations and improved coordination and control of air traffic.

Increased maritime traffic in Danish waters and increased use of bigger ships brings a heightened risk of accidents at sea. Meanwhile, however, stricter international regulations on ship construction and safety at sea, together with initiatives to improve how ships are monitored and guided through difficult or crowded passages, possibly with a Danish pilot, can help reduce the risk of future accidents in Danish waters.

On the railways, the amount of traffic in Denmark has likewise increased over recent years, but rail traffic generally has a high safety level. Safety systems such as ATC (Automatic Train Control) and HKT (speed control and automatic braking), combined with recent action to renew rails, signalling systems, etc., reduce the risk of major accidents.

On the roads, both the number of accidents involving minor injuries and accidents involving serious injuries and deaths has been markedly reduced in recent years. Speed limits, spot checks, speed-reducing devices, better signposting and increased use of safety equipment have all had positive effects.

An increased number of tunnels and bridges in Denmark, especially the current expansion of Copenhagen's Metro and the projected fixed link across the Fehmarnbelt, can, in principle, add to the risk of major transport accidents, but, here too, safety is a significant focus area.

Finally, it must be emphasised with regard to all transport forms, that the risk of major accidents is also gradually influenced by changes in the Danish weather due to global warming. As described above in sections 2.1 and 2.2, climate change can, inter alia, bring about more frequent and powerful episodes of strong winds, high waves and floods, which can be potentially dangerous for land transport, aviation and shipping alike.

2.6. Accidents with dangerous substances on land

Characteristics

Accidents with dangerous substances on land are most often either industrial accidents or land transport accidents, in which the characteristics of the involved substances in the event of fire, explosion or spillage – whether alone or in combination and whether immediately or in the longer term – constitute a significant hazard to persons, property and the environment.[5]

The term "dangerous substances" can refer to chemical, biological, radioactive and nuclear substances as well as explosives. This section will focus on accidents with dangerous chemical and explosive substances. It will give particular attention to flammable, explosive, poisonous (toxic) and environmentally harmful gases, fluids and solids.

Industrial accidents can arise from uncontrolled courses of events during production, use or other handling of dangerous substances; in connection with the storage of dangerous substances in tanks, depots or warehouses; and during loading, unloading or internal transport within industrial establishments.

The potential causes of industrial accidents are varied, but can essentially be classed as internal and external risks. Internal risks hinge on conditions or events inside an industrial establishment. This may, e.g., entail technical faults in equipment or systems, human error, unintended physical or chemical processes, build-up of static electricity or presence of other sources of ignition, etc. External risks hinge on conditions or events outside the establishment, e.g. extreme weather or industrial accidents in neighbouring establishments.[6]

Industrial establishments with large stocks of inflammable, explosive, poisonous or environmentally dangerous substances are characterised as high-risk (upper-tier) establishments. There are many kinds of high-risk establishments, of which oil-storage depots and refineries are among the biggest. The regulations for high-risk industrial establishments are administered by several authorities in Denmark and derive from an EU directive commonly known as the Seveso Directive, with reference to the Italian industrial accident at a chemical-processing plant in Seveso in 1976, which resulted in the treatment of up to 2,000 people for dioxin poisoning, the evacuation of over 600 people, and long-term environmental damage in a 25 km^2 area.

Land transport accidents with dangerous substances can arise from commercial transport of dangerous substances in road tankers, rail tankers, containers and other carriers. The potential causes may sometimes be the same as those described in section 2.5 regarding "ordinary" transport accidents (e.g. collisions and derailments), and at other times situations, where goods have been incorrectly handled during packaging or in transit (e.g. leakage). The responsibility for the regulations concerning transport of dangerous goods by road and rail is also shared among several authorities and based on two principal sets of rules: the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) and Regulation concerning the International Carriage of Dangerous Goods by Rail (RID).

Industrial accidents and transport accidents with dangerous substances can potentially happen in many places. In Denmark, there are around 150 high-risk industrial establishments, and some of them are situated

[5] This section deals only with industrial accidents and land transport accidents. Other types of accident with dangerous substances on land might be, e.g., the rupture of oil or natural gas pipelines, the spillage of ammonia from larger air-conditioning systems in shopping centres and other buildings that do not count as industrial installations, etc.

[6] In addition, one can add security threats with scenarios ranging from sabotage committed by a disgruntled employee to acts of terrorism or cyber-attacks mounted against industrial SCADA-systems (cf. sections 2.9 and 2.10).

in or close to densely populated areas, including, for example, seaports. Likewise, railway lines and road transport routes for dangerous substances pass through densely populated areas at a number of points, although, on the roads, there are compulsory routes for the transport of the most dangerous substances.

The lists of dangerous substances given in the Seveso Directive, ADR, RID, other EU regulations such as REACH and the directives on pesticides and biocides, together with the Danish authorities' executive orders and circulars, are long. Among the groups of poisonous gases, ammonia, for example, is one of the most commonly occurring dangerous substances in Denmark. Ammonia is found, inter alia, in flue-gas cleaning installations within power plants, refrigeration systems used in food production, and many other industries. Ammonia is stored under pressure as a liquid gas, and will therefore rush out in the event of a breach in tanks, pipes or suchlike. The gas is poisonous once it spreads through the air and can in certain cases create a danger of fire and explosion. Another example is the large storage tanks for inflammable fluids relevant to fuel supply security, which can be found at many locations in Denmark.

Possible consequences

Industrial accidents and transport accidents with dangerous substances seldom have catastrophic consequences, but there are exceptions. Both types of accident can cause violent conflagrations and explosions, which in turn can result in the death and severe injury of many people at or near the scene of the accident on account of shock waves, strong radiant heat, collapsing structures, spreading of smoke and flue gases, leakage of poisonous types of gas, etc.

The airborne spreading of large quantities of dangerous substances in densely populated areas can have particularly grave health consequences in the form of acute harm to persons. Beyond this, there may be derived psychological consequences for people who have been or fear that they have been poisoned.

Depending on an accident's complexity and extent, the scene of the accident may be fraught with dangers for rescue workers, e.g. risk of secondary explosions, uncontrollable spread of fire, sudden collapse of structures, unexpected leakage of dangerous substances, etc. Necessary safety measures for the benefit of rescue workers can therefore affect the performance of a large variety of urgent emergency response tasks.[7]

Furthermore, harm to persons can also occur if an accident with dangerous substances develops into a public attraction, e.g. if groups of curious spectators make access for rescue vehicles difficult, or if citizens do not follow the authorities' instructions to stay indoors, close windows, observe safety distances, etc.

Besides fires, explosions and poisonous emissions, there are other types of accident with dangerous substances with potential health consequences, e.g. if a food producing facility unsuspectedly becomes contaminated and its products are sold to consumers before they can be withdrawn.

The consequences for the local natural environment, including wildlife, plants, areas of land, lakes, creeks, streams and ground water, can also be large-scale and, in some cases, it takes several years to restore the environment when a locality has become polluted.

[7] E.g. searching for and freeing trapped people; evacuating persons in distress; fighting primary and secondary fires; cooling down tanks and the like to mitigate further danger of fire and explosion; supplying water and foam; reinforcing buildings; using heavy equipment to free trapped people, penetrate walls, etc.; using rescue cranes to remove parts of buildings or pieces of wreckage; using mobile HazMat units; sampling to identify dangerous substances; cleaning and decontaminating people and equipment; containing and collecting polluted water that was used to extinguish fire, etc.

In addition to consequences for life, health, well-being and the environment, accidents with dangerous substances can require large financial outlays. If an accident is caused by fire, an explosion, a collision or suchlike, there may be great material damage to nearby buildings, means of transport and infrastructure. At the same time, the work of cleaning and/or decontamination and the subsequent removal of polluted water and soil may be very expensive. If citizens have to be re-housed, that too can be a lengthy and costly process.

Finally, accidents with dangerous substances may have consequences for access to certain critical societal functions. For instance, the supply of drinking water to a locality may be seriously affected if dangerous substances seep down into the ground water, and in the transport sector it may become necessary to re-route traffic for a prolonged period.

The nature and extent of the possible consequences are highly dependent on the specific context and influenced by, among other factors:

- The quantity, location, liability to ignition and explosion, toxicity and environmentally harmful effect of the dangerous substances.
- The number and reliability of safety precautions, e.g. implemented to satisfy legal requirements in the field of prevention.
- Weather conditions at the time of the accident, including wind strength, wind direction and precipitation.
- The number of people in immediate proximity to the accident and its distance from the nearest dwellings and companies.
- The local environment's susceptibility to pollution, including the adaptability of the ecosystem.
- The effectiveness of warnings, the acute life-saving response, shielding and enforcement of safety distances, cleaning and decontamination, and the subsequent clearing up, secondary damage control and environmental reconstruction.

Past occurrences

The fire and explosion at N.P. Johnsen's Fireworks Factory at Seest near Kolding on 3 November 2004 was – seen in terms of the physical damage – Denmark's biggest industrial accident in modern times. The accident is presumed to have started when an employee, during the routine emptying of a 40-foot container, dropped a box of rockets, which ignited. The conflagration quickly spread to the remaining fireworks in the container and to fireworks lying on nearby pallets and in a neighbouring open container. Reduced visibility due to thick smoke made it difficult for emergency responders to get close to the two burning containers whereby the fire-fighting and cooling efforts were impeded. About an hour and a half after the fire started, there was an explosion in one of the containers, at a moment when the fire's intensity had been judged to be slackening off. The explosion killed a fire-fighter, while several other people were injured and suffered burns. At the same time, eight fire and rescue vehicles and other fire-fighting equipment were destroyed. The explosion caused the fire to spread to a nearby warehouse where over 800 tonnes of fireworks were stored. Three further explosions then occurred on the site, whereupon the whole factory and buildings in its vicinity caught fire. The explosions provoked earth movements corresponding to 2.2 on the Richter scale.

During the initial response phase, about 800 people took part in fighting the fire, including some 350 professional firefighters, 150 police officers and 300 Home Guard members. Besides the person who died, seven of the emergency responders were injured, two of them seriously. A total of 79 people from the fire and rescue services and the police were taken to hospital to be kept under observation for smoke poisoning, etc. Among the local residents, 17 suffered minor injuries. About 2,000 persons from 760 homes, together with workers from companies in the area were evacuated. Moreover, during the first year after the accident, around 100 children and 150 adults received psychological assistance via Kolding Municipality. A total of 12 companies were levelled, and there was damage to around 350 single family homes, of which many burnt to the ground or were rendered uninhabitable. The subsequent work of clearance, demolition, secondary damage control, environmental restoration and reconstruction went on for several years. The devastation is reckoned to have cost altogether DKK 750 million.

One of the most serious Danish transport accidents with dangerous substances in recent times occurred on 25 September 1992, when a freight train ran into a stationary passenger train at Næstved Station. The accident happened in the early morning, when no one was travelling on the passenger train yet, but several coaches were derailed and damaged. When it was first noticed that some liquid had leaked out, the immediate assumption was that it was merely diesel oil from a tank. Besides oil, however, it later became evident that liquid was pouring from an overturned rail tanker which contained over 60 m^3 of acrylonitrile. Acrylonitrile is a highly toxic and flammable chemical which, in addition, can form explosive mixtures with air. It can poison people through inhalation of fumes and through skin contact, and, when it catches fire, it can develop the even more toxic substance, hydrogen cyanide (also known as blue acid). The area around the overturned tanker was accordingly sealed off and covered in foam to prevent ignition and poisoning.

In all, 400-600 litres of acrylonitrile flowed out into the surroundings. The first result of the accident was that 52 people were brought to a hospital emergency ward, of whom 24 were admitted for observation. In all the cases, however, poisoning could be ruled out after clinical examination. The initial job of emptying, cleansing and removing the rail tanker and cleansing and preparing used equipment took relatively few days, but clearing up the ground around the railway track and the subsequent environmental restoration became extraordinary lengthy. Many thousands of litres of polluted water were collected daily over a long period, while over 300 m^3 of soil polluted with acrylonitrile and 155 m^3 of soil polluted with oil were removed. The environmental restoration was not complete until November 1996, more than four years after the accident.

Other examples of major Danish industrial accidents include:

- The explosion in a garage full of illegal fireworks in St. Andst, near Kolding, on 8 October 2011, followed by a fire which killed two people, while several households had to be evacuated.
- The violent fire in two tanks containing palm-oil in Aarhus Port in the summer of 2008, which the emergency service prevented from spreading to two nearby tanks containing the dangerous substance methanol.
- The explosion at Lindø Shipyard in 1994, when six employees were killed and 15 injured after 900 litres of diesel oil had been pumped into and vaporised in a fuel tank, which then caught fire during welding work on a super tanker.
- The explosion at the Danish Soya Cake Factory’s extraction plant in Copenhagen in 1980, which injured 23 people, necessitated thorough and lengthy cleaning of land plots and caused damages worth DKK 200 million.
- The pollution incident at Simmersted in 1972, when a tanker truck overturned, releasing large quantities of poisonous phenol close to Simmersted Waterworks, which had to shut down and was never reopened.
- The explosion at Valby Gasworks in 1964, when three workers died and a man in close proximity died of shock. About 200 people were injured and assets worth over DKK 35 million were destroyed.

Possible trends

The production, storage, use and transport of dangerous substances in Denmark are limited when compared with many other European countries, but will continue to be necessary, since these substances are used in many industrial processes, in power plants, in the food industry, in laboratories, in the health sector, for certain household products, etc.

Stricter regulations and phasing out of the substances most dangerous to health and the environment can to a certain extent affect, that there will be fewer dangerous substances in Denmark in the future, whereby the risk of some types of industrial accident will be reduced. At the same time, however, it should be stressed that certain dangerous substances, although they are not used to a large extend in Denmark, are shipped through Denmark. Generally, as remarked in section 2.5, we see an increase in the volume of transport which, other things being equal, also heightens the risk of transport accidents with dangerous substances.

Beyond this, the changes in the Danish climate, mentioned in sections 2.1 and 2.2, may perhaps also increase the risk of industrial accidents and transport accidents with dangerous substances caused by extreme weather phenomena.

The risk also grows with urban expansion, since a tendency for built-up areas to spread closer to existing high-risk industrial establishments can be witnessed. This underlines the importance of a continuous focus on risks in connection with land-use planning by authorities. In recent years, the authorities have generally improved their administrative practice regarding high-risk industrial establishments and the transport of dangerous substances, and focus on the effectiveness of regulations is expected to continue. In 2012, the revised Seveso III Directive was approved, and it must be implemented by the EU’s Member States not later than 1 June 2015. The directive contains, inter alia, regulations to ensure greater transparency for citizens on the subject of high-risk industrial establishments; clearer rules for public consultations and public involvement regarding the planning of new high-risk industrial establishments or of substantial alterations to or in the vicinity of existing ones; together with access to seek a review of the authorities’ decisions.

2.7. Marine pollution accidents

Characteristics

Marine pollution accidents are accidents, in which oil or chemicals spill into the sea and can cause damage to both the marine and the coastal environment. In certain cases, such spills may also endanger persons.

The pollution accidents can occur in connection with the shipping of oil or chemicals, when a ship runs aground or collides with another ship, a bridge or an offshore platform. The cleaning of ships' tanks, transfers between ships, accidents with offshore drilling platforms, spills on land near to the coast, creeks or streams, and pipeline leakages may also cause the discharge of oil or chemicals into the sea. Minor oil spills with relatively limited consequences happen every year in Danish waters. However, it is the consequences of much bigger oil spills, e.g. if a super tanker is wrecked, that represent the greatest risk. Chemical spills are rare in Danish waters compared to oil spills, but they can entail serious consequences, depending on the size of the spill and the composition and properties of the chemicals in question.

The amount of shipping traffic through Danish waters is considerable and includes a large number of oil and chemical transports. Collisions entail the greatest risk of spills. This risk is assessed to be highest in the northern part of the Kattegat near No. 1 Buoy, in the Great Belt/Langeland Belt, in the Sound and in the Bornholm Gatt between Bornholm and Sweden. Groundings occur relatively often in Danish waters, but rarely leads to oil or chemical spills, partly because the seabed around Denmark is chiefly made up of sand and other soft material. Exceptions are the bedrock and reefs off Bornholm and Hatter Barn in the Kattegat.

Oil or chemicals spilt in Danish waters can potentially spread over a very wide area, depending on the weather conditions and the local geography. Pollution by oil and chemicals can harm both the marine and the coastal environment and have extraordinarily serious consequences if affects areas that are particularly vulnerable or of ecological importance. Examples of ecologically important areas in Denmark are those included in the EU's network of protected nature reserves (Natura 2000). Depending on the character of the spill and the locality, the consequences will not necessarily last for long, however. With time, most pollutions disappear through natural processes of degradation (weathering). These processes are speeded up by warm temperatures, and there are signs that areas recurrently exposed to pollution adapt to it more readily.

The handling of urgent marine pollution accidents is the responsibility of state and municipal emergency operators and often requires use of resources on a large-scale. With oil spills, an attempt will most often be made to contain the oil with floating barriers and then to suck the oil into tanks or containers. Chemical spills are generally more difficult to deal with, since chemicals are so diverse. Sinking and soluble chemicals are impossible to remove. Compared to the number of oil transports, there are few chemical transports in Danish waters, but there is also more limited experience with responding to the wide range of potential challenges that chemical spills at sea may pose.

There are a number of designated refuges in Denmark to which damaged ships can be towed in order to prevent oil or chemicals from spreading to wider areas of the sea or to coastlines, which are either especially vulnerable or of ecological importance, or if other conditions will impede the anti-pollution response.

Possible consequences

Oil spills at sea can involve a risk to human life or health, and toxic fumes from spillages of e.g. fuel oil or crude oil can potentially harm ships' crews. Chemical spills can, depending on the composition of the chemical substance and on the emergency countermeasures, represent a still greater risk to people, e.g. due to danger of fire, explosion, chemical burns, oxidisation, toxicity or radioactivity.

The environmental consequences will, inter alia, depend on the composition of the oil or chemicals, the extent of the spill, the timing of the spill, the effectiveness of counter-measures and clean-up work, and the vulnerability within the exposed area – including the pace of environmental changes vis-à-vis the ecosystem's adaptability. With oil spills, the largest environmental consequences are pollution of coastlines and harm to animals and plants. Birds are particularly vulnerable to even small amounts of oil. Whenever a bird comes into contact with oil, its thermo-insulation is reduced, and it dies unless it can be cleaned. Oil pollution can also bring about changes in birds' behaviour, food absorption and reproduction. If a large part of a local breeding stock is wiped out, it takes a long tine to build up again. Moreover, where concentrations of oil are very high, both birds and mammals can suffer internal injuries from eating oil-contaminated food or through poisoning.

The economic costs of dealing with major oil or chemical pollutions, including the cost of collection, cleaning, restoration, storage, etc., can be very considerable. Furthermore, major pollution accidents can have a whole range of socio-economic consequences in areas that depend on a clean marine and coastal environment. Since tourism constitutes an important commercial sector, with a high concentration in coastal municipalities, both the tourism sector and local communities may suffer income losses following a major pollution accident. Other commercial sectors that may be affected include fisheries, fish farming, agriculture, and raw materials extraction. Depending on the location of the spillage and the extent and duration of the response and clean-up operations, there may also be inconvenience to shipping, for instance if a sea route is blocked or a port is sealed off.

Past occurrences

The biggest oil pollution accident in Danish waters to date occurred on 29 March 2001, when the oil tanker Baltic Carrier collided with the cargo ship Tern near Grønsund, in the waters south-east of Falster. The collision resulted in a spill of approx. 2,350 tonnes of heavy fuel oil from the Baltic Carrier's total load of around 33,000 tonnes. Difficult weather conditions impeded the recovery of the oil out at sea, but, once it had drifted into calm waters west of Farø, it was possible to collect some 1,100 tonnes. The rest of the oil, which had the consistency of thick liquid asphalt, drifted onto the eastward coasts of Møn and Falster, as well as into the Grønsund, where the clean-up operation continued with digging machines, suction vehicles and shovels. On the coast, the oil became mixed with sand, stones and vegetation, adding to the clean-up difficulties and producing unexpected quantities of refuse, which at first created storage problems, since there had been no plans for depots on land. After two weeks' work, some 3,950 tonnes of oil and oil-polluted matter had been collected. The Grønsund is an important breeding ground for birds, and close on 20,000 of them died. Records show, however, that the bird population has since stabilised in the area. The prompt and efficient clean-up work is assessed to have played a substantial part in minimising the effects of the pollution. The time when the spill occurred, before the start of the holiday season, also helped to limit the negative consequences for local tourism.

Another major oil spill in Danish waters occurred on 31 May 2003, when the Chinese cargo ship Fu Shan Hai sank off the northern point of Bornholm after colliding with the container ship Gdynia. The Fu Shan Hai was carrying artificial manure and had around 1,680 tonnes of bunker oil in its fuel tanks. Part of the bunker oil flowed out into the Baltic Sea, about three kilometres from the coast. It spread to the coastline around the Ertholmene island group and large areas of south-eastern Skåne and caused 1,000-1,500 birds to die.

An example of how even a smaller oil spill can wreak considerable damage in places far away from the scene of the spillage occurred on 2 August 1985, when the West German tanker Jan rammed into a lighthouse at Hals Barre, near the entrance to the Limfjord. The tanker was carrying some 3,000 tonnes of heavy fuel oil, and the collision made a gash in the hull, causing a spill of around 200 tonnes from two cargo tanks. Partly because of the location, emergency response vessels did not arrive until 10 hours after the collision, by which time the oil had drifted 10-12 kilometres north-east and spread over a considerable area. Since weather conditions had worsened in the meantime, it was impossible to stop the oil from reaching the south-western part of Læsø. Here, a sizeable coastal area consisting of wide salt marshes was polluted, and a large number of birds were affected. Cleaning up salt marshes is very difficult and requires specialised equipment. Thus, the cleansing of the Læsø salt marshes kept about 150 people working for over two weeks, and necessitated the laying down of temporary roads in the inaccessible and environmentally sensitive areas. Moreover, a further oil spill of 100 tonnes occurred while the tanker was being disengaged from the lighthouse at Hals Barre.

Finally, the sinking of the oil tanker Prestige in 2002 must be mentioned as one of the accidents which have contributed to forming the present international regulations concerning safety and prevention of pollution at sea. Although it happened abroad, this shipwreck is of relevance to the Danish national risk profile because the Prestige had passed through Danish waters on its way from Latvia to Singapore. The accident began with a collision with a floating container whereby one of the ship's 12 tanks burst. The crew asked for a port of refuge in France, Spain and Portugal, but were denied admission because the authorities did not want to risk a major oil spill close to land. Six days later, the ship sank some 200 kilometres off the Spanish and Portuguese coasts. The oil that had not already leaked out following the collision now continued to leak from the wreck on the seabed, constituting a series of major and minor spills in 2003 and 2004. Despite action to collect the spilt oil, it is estimated that 63,000 tonnes of it has leaked from the wreck, making this accident one of the most disastrous cases of oil pollution in Europe so far.

Possible trends

Oil and chemical pollution accidents in Danish waters have hitherto been relatively limited. However, the risk of more and bigger spills is anticipated to grow in the future, depending on a number of factors. Shipping through Danish waters is generally reckoned to rise by 25 pct towards the year 2020. This includes oil shipments, and, in particular, the export of oil from Russia is expected to grow. Moreover, the size of ships is expected to increase, which primarily will add to the pressure on the passages through the Great Belt and the Skagerrak. Combined with the fact that Danish waters can be difficult to navigate, this will, other things being equal, heighten the risk of a collision or shipwreck resulting in oil pollution on a scale never yet encountered in Denmark. The same applies to the risk of major chemical spills, which is generally considered to be greatest in the Sound. A risk analysis concerning oil and chemical pollution in Danish waters, commissioned by the Ministry of Defence in 2007, declared an expected rise in the number of accidents in Danish waters with harm to the marine environment, escalating by 22 pct up to 2015 and by 45 pct up to 2020.

Climate change can potentially also influence the risk of marine pollution accidents, since strong winds and high waves increase the danger of shipwrecks and, in the long term, can also mean worsened wear and tear on maritime infrastructure. As has been mentioned in section 2.1, trends in extreme wind conditions are one of the subjects on which climate models show the most uncertainty, but a general intensification of west wind in the northern part of the North Atlantic is noticeable, whereby the North Sea in particular becomes more exposed.

On the other hand, the risk of marine pollution accidents may be reduced with the help of the many preventative measures being initiated. For instance, international regulations on ship construction may mean that larger vessels become better able to withstand collisions and groundings. The development of technical tools and procedures for monitoring ships at sea and guiding them through difficult or crowded passages, possibly with a Danish pilot, can similarly help to prevent future accidents in Danish waters. Beyond this, international cooperation to exchange information and agreements on mutual assistance in case of major accidents will continue to be of great importance.

Finally, as mentioned above, there may also be a risk of oil spills in connection with prospecting, production and transport of oil by pipeline from offshore installations in the North Sea. However, this risk is considered less than that for shipping.

2.8. Nuclear accidents

Characteristics

A nuclear accident is defined by the International Atomic Energy Agency (IAEA) as an accident at a nuclear facility where nuclear materials are produced, processed, utilised, treated, stored or deposited. The term "nuclear materials" here refers exclusively to plutonium and enriched uranium. Thus, nuclear accidents are to be distinguished from radiological accidents. Radiological accidents can occur elsewhere than at nuclear facilities and can involve radioactive material other than plutonium and enriched uranium. The difference between the two types of accident is also reflected in the definitions of nuclear safety and radiation safety.

The nuclear facilities where a serious nuclear accident could potentially entail major consequences for Denmark are first and foremost nuclear power plants situated in European countries. Nuclear power plants occupy a distinct position as possible sources of nuclear accidents because of their very large content of fission products, which gives potential for serious scenarios involving airborne spread of radioactive contamination over great distances.

This section will therefore focus on the risk of a nuclear accident at a nuclear power plant abroad. It must be emphasised, however, that there are other possible sources for either nuclear or radiological accidents. These include, inter alia*,* installations for producing and treating reactor fuel; nuclear-powered vessels; the crash of a satellite with a nuclear power source; storage facilities and depots for used fuel; transports of used fuel[8]; and powerful industrial sources, e.g. radiographic sources. In this connection, it should also be mentioned, that it was decided in Denmark in 2000 to shut down the last two out of three experimental reactors at the then Risø Research Centre. Two of the reactors are now decommissioned, while the used fuel rods from the third reactor (DR 3) were returned to the USA in 2002. The dismantling of DR 3 is planned for 2018-2020, although the final depository for nearly 10,000 cubic metres of low and medium radioactive waste has yet to be decided on.[9]

The nuclear power plant in operation closest to Denmark is the Ringhals plant in Sweden. This plant has four reactors and is situated near Gothenburg, about 55 km from the island of Læsø. Beyond this, there are four plants in northern Germany, between 105 and 160 km from the Danish border. Three of these have been shut down following a decision to phase out nuclear power in Germany after the nuclear accident at the Fukushima Dai-ichi plant in Japan in 2011. However, the German plants are still operable. Further away from Denmark can be mentioned, inter alia, two Swedish plants, respectively in Småland and north of Stockholm. Altogether, there are around 200 reactors in Europe, half of which are closer to Denmark than Chernobyl, where the world's most serious nuclear accident up till now took place in 1986. At present, there are 132 working reactors in 14 EU Member States (Belgium, Bulgaria, Czech Republic, Finland, France, Germany,

[8] The exact number of transports of used fuel and other nuclear materials in international waters near the coast (Danish channels and belts) is not known, since ships in routes with status of international waters are not obliged to disclose details of their cargo. However, the National Institute for Radiation Protection (SIS) at the Danish Health and Medicines Authority has stepped up cooperation with the Maritime Assistance Service (MAS), a branch of the Danish Naval Command, to maximise opportunities for tracking ships whose cargo comes under the INF Code (International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships).

[9] Given the abovementioned IAEA definition, a radiological accident could in principle occur with the DR 3 reactor, but not a nuclear accident, since the fuel elements have been removed and DR 3 can no longer be termed a "nuclear facility" (although DR 3 is classed by the Danish supervisory authorities as a shut-down nuclear installation). According to the IAEA definition, a nuclear accident at the Risø site could only happen in the case of an accident with the 233 kg of used fuel, the enriched uranium in the fuel box, the DR 1 core, or possibly the concrete cells of the Hot Cell installation.

Hungary, the Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden and the UK). The rest are situated outside the EU in, among other countries, Russia, Ukraine and Switzerland.

The greatest danger in operating nuclear power plants is the risk of radioactive material being released from the reactor fuel and spreading. Three conditions in particular are seen as liable to cause a release to the environment: loss of control over the chain reaction process without a safe shutdown; insufficient cooling followed by damage to the fuel; and insufficiently effective containment to withhold the radioactive material after the fuel has been damaged. The possible underlying causes may, for example, be technical weaknesses in systems, human errors or the results of other incidents such as natural disasters.

In contrast to some nuclear power plants in Eastern Europe, the reactors at the nuclear power plants nearest to Denmark are all enclosed in a reactor containment to hold back radioactive material in the event of a serious accident involving damage to a reactor tank. The reactors are equipped with mechanisms for keeping pressure and temperatures down and also with a pressure relief system which can lower the pressure inside the reactor containment. In most cases, this is done by sending some of the gas content through a filter so that the reactor containment is not damaged by excessive pressure. At the same time, such a filter can also confine the majority of the radioactive particles from escaping into the environment in the event that a controlled release might become necessary.

Possible consequences

If there is a release to the atmosphere following an accident at a nuclear power plant, the amount and character of the radioactive material combined with meteorological conditions will be decisive for which way the material travel, and hence for the consequences of the release. It is the accident's precise course of events which determines how much radioactive material will escape into the environment. If the release is gaseous, the nature of the radioactive contamination in the spread-direction will thereafter depend partly on the distance from the plant, partly on wind speeds and washout by rain or other precipitation. Contamination in Denmark could thus occur locally, regionally or nationwide, depending on the specific course of events.

It is therefore also difficult to estimate the possible consequences of nuclear accidents for Denmark. The general rule is that, the further away the source of the release is from Denmark, the less radioactive contamination there will be in Denmark. However, a gaseous release can under certain weather conditions travel a long distance with relatively little fallout on the way, followed by much larger fallout later in connection with precipitation, which can cause considerable contamination far from the source of the release.

Irrespective of the weather conditions after an accident at one of the nuclear power plants nearest to Denmark, it is not expected that direct irradiation through air pollution and inhalation of radioactive material, nor intake by way of food and drinking water, can cause people in Denmark to suffer acute radiation injuries. Depending on the effectiveness of the precautions taken by the authorities and citizens, there may be a risk of injuries that develop over time, chiefly a small but indemonstrable increase in cancer cases. Health consequences of a psychological nature are also possible in both the short and long term. These could, for example, take the form of traumas or general anxiety induced by the accident itself, or of stress and insecurity if, contrary to expectation, it proves necessary to evacuate citizens.

Since a serious nuclear accident has the potential to contaminate vast areas of land, the financial cost of cleanup after the contamination can also be considerable. Agriculture could be particularly affected, since it might be necessary to destroy crops and cull farm animals in order to avoid food contamination and since there could be indirect consequences for the food supply and the part of the population whose income depends on agriculture. Loss of income may likewise afflict fisheries, sea and pond fish farming, etc. The foodstuffs industry in general and food export companies in particular may thus potentially suffer great losses.

A further consequence may be radioactive contamination of buildings and infrastructure, which can necessitate heavy expenditure on decontamination. More generally, the value of properties and land plots in town and country can depreciate as the result of contamination. Beyond this, even a limited degree of contamination – or the mere suspicion of possible contamination – may keep tourists away for a period, with derived consequences for the tourism industry and the economy in affected local communities generally.

Finally, a nuclear accident could put considerable pressure on the Danish authorities, even if the accident happens so far away from Denmark, that none of the aforementioned consequences occur within Danish territory. The reason would be a great need for information among citizens both in Denmark and Danes near the site of the accident. This can necessitate a lengthy crisis communication task regarding health related countermeasures, etc.

Past occurrences

Two nuclear accidents abroad have had limited direct or indirect consequences for Denmark: the Chernobyl accident in the former Soviet Union in 1986 and the Fukushima Dai-ichi accident in Japan in 2011.

The Chernobyl accident was the world's most serious nuclear accident to date. It happened on 26 April 1986 after one of the reactors at the nuclear power plant in Chernobyl went out of control during a test as part of a routine shutdown procedure. This caused an explosion and set the reactor core on fire. For 10 days, large quantities of radioactive material went up into the atmosphere to a height of several kilometres, and the release could therefore be carried with the wind over long distances. Because of shifts in the wind's direction, the radioactively contaminated cloud drifted across most of Europe. In Denmark, a minor increase in the radiation level was detected, but there was no significant contamination, since precipitation was very limited at the time when the radioactive cloud passed over the country.[10] In parts of Sweden, on the other hand, it rained heavily, whereby large quantities of radioactive material were washed out and caused contamination.

The Fukushima Dai-ichi accident started on 11 March 2011, when Japan was hit by a powerful earthquake, followed by a tsunami which caused widespread devastation along the country's east coast. Several Japanese nuclear power plants were damaged, but none so seriously as the Fukushima Dai-ichi plant, about 250 km north-east of Tokyo. The damage left by the tsunami meant that several of the plant's emergency systems were out of action, obstructing the cooling of the fuel elements in several of the plant's six reactors. Since most of the supervisory systems went down simultaneously, there was insufficient overview of the situation. A series of explosions occurred in several of the reactor buildings, and there were periods when a highly elevated radiation level was registered. Because of the distance to Japan, there was no risk of direct consequences in Denmark, but Danish authorities, businesses and citizens at home and abroad had to come to terms with a range of indirect consequences. On account of the situation at the Fukushima Dai-ichi plant, which deteriorated in the days after the earthquake and the tsunami, advice was supplied by DEMA and the National Institute for Radiation Protection (SIS) at the Danish Health and Medicines Authority, inter alia, in conjunction with the travel advisory for Japan issued by the Danish Ministry of Foreign Affairs. For a period, it was recommended that Danes residing less than 80 km from the plant should move away. It was also recommended for a period that all journeys to Japan should be called off.

[10] Slightly heightened levels were registered in Denmark in soil, grass, crops and milk due to a very limited, but measurable, dry-deposit of caesium and strontium.

Possible trends

Recent years have seen a renaissance in nuclear power as an alternative source of energy production to fossil fuels. The Fukushima Dai-ichi accident in 2011 brought about that some countries are now phasing out or scaling down the use of nuclear power in their energy supply. Germany has decided to phase out nuclear power by 2022, while Switzerland will shut down its nuclear power plants when their technical lifespan expires. Worldwide, however, a continued expansion of nuclear power is still taking place, and this is also the case in Europe. Russia, for instance, has significantly opted for nuclear power in its future energy production. Russia is in the process of building new nuclear power installations on a number of sites, and, among others, a plant is expected to be completed in 2016 in Kaliningrad, about 450 km from Bornholm. Some of the smaller Eastern European countries are also building nuclear power plants, and Poland currently has plans in place to build four installations – probably within a distance of 100 to 200 km from Denmark. Further away from Denmark, the building of a new plant in Finland is nearing completion.

The risk of nuclear accidents with consequences for Denmark logically depends on the number and relative proximity to Denmark of present and future foreign nuclear power plants, but first and foremost on the individual plants' robustness, including technical standards, organisation, regulatory control and safety culture.

There have been safety incidents at a number of European nuclear power plants in recent years, and, in the wake of the Fukushima Dai-ichi accident, the European Council decided in March 2011 that all nuclear power plants in the EU's Member States should undergo 'stress tests' to uncover whether they could withstand a range of natural and man-made incidents. Stress testing started on 1 June 2011, and on 4 October 2012 the European Commission published a report on the results. The report concluded that the safety level is generally high and that there are no grounds for recommending any plant closures, but also that safety improvements are required at most of the plants. Among other faults, a certain number of the plants have yet to implement some of the safety standards recommended by the IAEA. Similarly, it is pointed out that several of the plants fall short of the international "best practice" targets in key areas such as:

- Risk assessment in relation to earthquakes and floods: Many plants have undertaken a risk assessment within a time scale shorter than 10,000 years, which is the international standard.
- Seismic measurement equipment: Some plants have not installed equipment for measuring earthquakes.
- Filtered venting systems: Not all the plants have established a filtered venting system, which makes it possible to reduce pressure inside a reactor containment in order to limit possible contamination of the outside environment in case of accident.
- Emergency equipment for combating serious accidents: Many plants have not established secure areas where personnel can quickly access emergency equipment for use in the event of serious accidents.
- Backup control room: A number of the plants are constructed without an extra control room which can be used if an accident prevents use of the main control room.

The authorities in the individual countries must now draw up plans for implementing the improvements, and the Commission is planning jointly with the national supervisory authorities to produce a report in June 2014 on the carrying out of the Commission's recommendations. Furthermore, the Commission is expected to propose a revision of the existing directive on nuclear safety in 2013. Beyond this, the Commission is working together with countries outside the EU, such as Russia, Ukraine, Armenia and Switzerland, on assessment of their nuclear power plants.

2.9. Terrorist acts

Characteristics

In the Danish Criminal Code, the term "terrorist acts" covers a whole range of serious crimes (e.g. murder, bombing, arson, kidnapping, aircraft hijacking, etc.) which are perpetrated *"with the intent to frighten a population to a serious degree or to unlawfully coerce Danish or foreign public authorities or an international organisation to carry out or omit to carry out an act or to destabilise or destroy a country's or an international organisation's fundamental political, constitutional, financial or social structures […], when the act due to its nature or the context, in which it is committed, can inflict a country or an international organisation serious damage".* The Criminal Code's provision regarding terrorist acts was adopted in 2002. The scope of the provision was set in accordance with the EU's Framework Decision of 2002 on combating terrorism and a Council Statement defining terrorism approved at a Council meeting in December 2001.

The Center for Terror Analysis (CTA) within the Danish Security and Intelligence Service continually assesses the terror threat to Denmark and Danish interests abroad. The current Assessment of the Terror Threat to Denmark (VTD) report can be found on pet.dk. The following extract from the report outlines relevant characteristics of the terror threat to Denmark:

"The terror threat to Denmark is transnational in nature. Thus, the threat to Denmark is closely linked to developments in the global threat picture. Threats to Denmark often have direct links to foreign countries, for instance when attack planning takes place via contact to international terrorist networks, following trips abroad, or when perpetrators enter Denmark from another country.

International counter-terrorist efforts have weakened the al-Qaida network in Pakistan/Afghanistan. However, the al-Qaida Senior Leadership remains active in terms of planning and trying to execute terrorist attacks against the West. At the same time, there are other terrorist groups, especially in Pakistan, with the capacity to strike against Western targets, also outside the region.

The political changes in the Middle East and North Africa have altered conditions for terrorist groups in the region. In a number of cases, the upheaval has weakened local security institutions. This has increased the latitude for terrorist groups, and new safe havens have emerged for terrorist groups to train and plan their attacks.

In this increasingly fragmented threat picture, regional terrorist groups in the Middle East and North Africa have gained in relative importance. While regional groups are generally focused on local issues and targets, many of them share the al-Qaida vision of Islamic rule and look upon the West as an obstacle hereto. Attacks against Western targets in the region or in Western countries will therefore remain an element of the planning efforts within such groups. The potential terrorist targets and the modus operandi of the groups vary, depending for instance on local interests. Thus, the threat picture has become increasingly dynamic. The terrorist groups continuously develop new attack methods, while actively and persistently trying to test and bypass security measures. Comprehensive, complex attacks are still being planned, but calls are increasingly being made for attacks using simple means, requiring less planning, or for solo terrorism where an individual acts alone.

The upheaval in the Middle East and North Africa has also led to new conflicts. The rebellion in Syria has been particularly attractive to individuals resident in the West, including Denmark. This has increased the risk of these individuals coming into contact with militant Islamist networks, including al-Qaida-affiliated networks. Other conflict zones, including Yemen, Somalia, Pakistan and Afghanistan, continue to attract individuals resident in the West.

Other terrorist groups or organisations that use terrorism as a means may also have an interest in striking against targets or interests in Denmark as part of a local or regional conflict or in response to political disagreement with the West. In the past year, there have been examples of such groups seeking to strike against Israeli and Jewish targets around the world, including Europe.

In political extremist circles – both left- and right-wing – the will to use violence continues to rise. The financial crisis in Southern Europe, especially in Greece, has led to violent clashes and attacks on foreigners perpetrated by individuals with a background in right-wing extremist circles. In Germany, right-wing extremists have carried out targeted attacks against Muslims. At the same time, right- as well as leftwing extremist circles increasingly direct their violent activities against state institutions. There are signs that the terrorist attack in Norway on 22 July 2011 has inspired like-minded individuals in other European countries.

While the global terror threat as such has not increased, the current overall threat picture against the West and Denmark appears more fragmented, dynamic and complex. The terror threat has thus become increasingly unpredictable."

Possible consequences

Generally, the possible consequences of a serious terrorist act will first of all be dead and injured victims. Furthermore, the damage site may present dangers to emergency responders. Beyond this, there may be grave psychological consequences for survivors, even if they have not suffered physical injuries. This may be a matter of e.g. traumas, anxiety, stress and insecurity, which may set in immediately after the attack or much later, and which may be temporary, prolonged or permanent. Relatives to victims may experience similar symptoms, and a fear-generating effect may spread through the general population.

Terrorist acts may also result in damage to or loss of property, especially in the case of bomb attacks. Even if the actual target of bomb attacks is people, shock waves, heat, fire and smoke can cause destruction throughout the immediate vicinity of the explosion and to surrounding buildings, infrastructure, etc. This can not only lead to high costs for clearing and rebuilding, but also to a range of indirect consequences. For instance, a public authority or private company – whether attacked as the intended target or randomly because of a location near the target – might experience absence and resignations among its staff due to fear of further attacks, or loss of reputation and revenue due to reduced confidence from external parties.

Likewise, physical damage to or possibly contamination of buildings, infrastructure and equipment may bring about indirect consequences for the continuance of critical societal functions near to – or, under certain circumstances, far from – the crime scene. This may, for example, include lengthy and geographically extensive disruption to public transport or to the provision of IT and telecommunication services, electricity, drinking water, etc.

Past occurrences

Compared to most other European countries, Denmark has so far been spared major terrorist attacks. In recent years, the threat has primarily come from militant Islamism, and, several times since 2008, militant Islamists in Denmark and abroad have planned and attempted to carry out attacks against individuals and locations with affiliation to the Cartoon Case.

On 29 December 2010, three men of Tunisian, Lebanese and Egyptian origin who had entered Denmark from Sweden were arrested in a flat in Herlev by the Special Intervention Unit of the Danish Security and Intelligence Service. They were suspected of being about to carry out a plan to force their way into the Jyllands-Posten/Politikens Hus news corporation in Copenhagen and kill as many people there as possible. At the time of their arrest, they were in possession of a machine pistol, a pistol, ammunition and 200 plastic strips that can be used for tying people's hands. The three men and a fellow conspirator in Sweden were all sentenced in June 2012 to 12 years' imprisonment.

On 10 September 2010, a male traveller of mixed Chechen and Belgian origin unintentionally exploded a bomb in a lavatory at the Hotel Jørgensen in Copenhagen, whereby he sustained injuries himself. It is assessed that he was in the process of finishing a parcel bomb for use against the Jyllands-Posten newspaper's office in Viby. He was sentenced in May 2011 to 12 years' imprisonment for attempting a terrorist act and contravening the weapons law.

On 8 July 2010, the Norwegian security service PST arrested three persons on suspicion of intending to carry out one or more terrorist acts. Two were arrested in Norway and the third in Germany. In October 2012, two of the persons were sentenced to eight and three years' imprisonment respectively for planning a terror attack on Jyllands-Posten and the cartoonist Kurt Westergaard. The third person was sentenced to 120 days' imprisonment for having purchased hydrogen peroxide, which can be used as an ingredient in bombs. Appeals against the sentences were since lodged with the Norwegian Supreme Court.

On 1 January 2010, a 28-year-old Somali man with a Danish residence permit forced his way into Kurt Westergaard's home in Aarhus. Armed with an axe and a knife, he tried to hack through the door into a secured room where Kurt Westergaard had taken refuge and activated his assault alarm. The perpetrator was arrested soon after and has since been sentenced to 10 years' imprisonment for attempting a terrorist act in the form of attempted murder.

In the autumn of 2009, two persons of Pakistani-American origin were arrested in Chicago for planning a terrorist attack against Jyllands-Posten. The two men had gathered information on possible targets, and one of them had visited and filmed Jyllands-Posten's offices in Aarhus and Copenhagen as well as carried out reconnaissance of alternative targets. They also examined the possibilities for assassinations of Kurt Westergaard and Jyllands-Posten's cultural editor. The attack was planned by militant Islamists connected with the terrorist group Lashkar-e-Tayyiba (LeT), which was responsible for the attack in Mumbai in India in 2008 that cost over 150 lives, and for which one of the two men has also admitted to having carried out part of the reconnaissance.

Other recent Danish cases involving militant Islamist terrorist activity include, inter alia, the Glasvej terror case in Copenhagen, for which two persons received lengthy prison sentences in 2008, and the Vollsmose and Glostrup terror cases, for which several persons received lengthy prison sentences in 2007 and 2008.

Further back in time stands out the hitherto only major bomb attack committed in Denmark, which took place on 22 July 1985 in central Copenhagen. First, a bomb exploded outside the office of the American company Northwest Orient Airlines on Vester Farimagsgade. A few minutes later, a second bomb went off outside the Jewish Community synagogue on Krystalgade. A third bomb, discovered in Nyhavn, was probably intended for the office of the Israeli airline El Al. On Vester Farimagsgade, a few people were injured and one died of injuries a few days later. On Krystalgade, 27 people were injured. A Shiite Muslim terrorist organisation claimed responsibility, and three Palestinians were sentenced to life imprisonment in 1989.

Possible trends

A review of possible trends is found in the following extracts from the CTA's current assessment of the terror threat against Denmark:

"CTA assesses that the terror threat to Denmark remains significant.

As a Western country with an active foreign and security policy, Denmark is a target of international terrorist groups in the same way as other Western countries. However, as a result of the Cartoon Case, Denmark continues to be of particular interest to militant Islamist terrorist networks.

The reprinting of the cartoons of the Prophet Mohammed in February 2008 caused militant Islamists in Denmark and abroad to label Denmark a high-priority terrorist target. On a number of occasions since 2008, militant Islamists in Denmark or abroad have planned or attempted to carry out attacks in Denmark or against Danish interests abroad. The preparation of a terrorist attack against the Danish newspaper domicile JP/Politikens Hus in Copenhagen in December 2010 serves as an example of this.

New international cases, which have been perceived as insults to Islam, have not weakened the interest in Denmark. This is due to a common perception among militant Islamist networks that Denmark, with the Cartoon Case, is responsible for starting these cases and that Denmark has not yet been punished sufficiently. The threat continues to be mainly directed against individuals and locations with affiliation to the Cartoon Case.

It seems likely, however, that militant Islamists who act independently or with contact to international networks will increasingly take the initiative to identify other terrorist targets. This might include targets deemed to be of symbolic value, including public or military institutions. It might also be easily accessible and unprotected targets. Experience from other Western countries shows that attacks against public transport systems or crowded places have a significant psychological effect on the public.

In recent years, the trend has been for militant Islamist groups to call for the planning and execution of solo terrorism against such easily accessible and unprotected targets. Such incitement from militant Islamist groups may also inspire individuals with no particular affiliation to Denmark to travel to Denmark to commit an act of terrorism.

There have been examples in Denmark of planning or execution of terrorist acts that have involved individuals who have been to conflict zones or who have engaged in combat, acquired military skills or established links with militant Islamist networks. The number of individuals from Denmark who choose to travel to conflict zones, including Syria, is growing. Going to a conflict zone does not necessarily mean that an individual is bound to commit terrorism. However, it increases the risk of contact with militant Islamist networks, which – along with other influences of a conflict zone – could make a person more susceptible to radicalisation and motivated to carry out terror-related activities upon his or her return. It might be in relation to an existing militant Islamist network or as a solo terrorist attack with the individual acting alone.

There have been a few examples where Danes going to conflict zones have been affiliated with criminal circles in Denmark, including gang-related circles. Thus, there is a risk that militant Islamists in Denmark may gain access to weapons, ammunition and other related items from such criminal circles.

In Denmark, there is also a risk that individuals may choose to commit terrorism as a result of perceived injustice or other influences, including stories in the media or on the internet, even without having had any direct contact with terrorist groups. However, the influence asserted by personal contacts and social relations as well as specific experience, e.g. from a training camp or conflict zone, remain key factors for understanding why someone decides to commit terrorism.

Small groups and individuals associated with political extremist circles in Denmark pose a certain terror threat. In the propaganda used by left- and right-wing extremists in Denmark, the image of the enemy appears to comprise perceived political opponents or certain minority groups. However, as seen abroad, violent activities of both wings may also be directed against state institutions, including the police, foreign embassies or private organisations or companies thought to be of symbolic value, e.g. from an anti-capitalist or xenophobic perspective.

CTA assesses that there may be individuals or groups in Denmark create their own militant ideology on the basis of various right-wing extremist ideas. The terrorist attacks in Norway on 22 July 2011 and other events abroad may have an inspiring effect on individuals and groups in Denmark. There are individuals in Danish left-wing extremist circles with the will and capacity to commit serious, violent crimes, including arson and attacks on political opponents.

Attempted terrorist attacks can take place without prior intelligence-based indications, i.e. without warning. The possibility of carrying out a terrorist attack depends on the security measures in place to protect potential targets and on the capacity of the terrorists.

When it comes to the capacity to carry out a terrorist attack in Denmark, it is the assessment of CTA that

the capacity exists to carry out terrorist attacks using easily accessible weapons, including stabbing weapons, small arms, incendiary bombs or small, home-made bombs that can be manufactured using commercially available products;

- the capacity exists to carry out terrorist attacks using easily accessible weapons, including stabbing weapons, small arms, incendiary bombs or small, home-made bombs that can be manufactured using commercially available products;
- the capacity to use simple chemical substances for terrorist purposes can be acquired;
- the capacity to carry out complex terrorist attacks in Denmark, which require lengthy planning, large material expenses and multiple perpetrators, is limited;
- terrorist groups do not currently hold the capacity to carry out targeted and disruptive cyber-terrorist attacks against IT or telecommunications infrastructure to adversely affect Danish society;
- terrorist groups do not hold the capacity to carry out terrorist attacks using biological, radiological or nuclear material.”

2.10. Cyber-attacks

Characteristics

Cyber-attacks are electronic attacks directed against information and communications technology (ICT), such as computers, servers, systems, networks, services, etc., which are directly or indirectly connected to the internet. Cyber-attacks can be cases, where the internet is used as a tool to damage or destroy ICT, to gain control over ICT, and/or to gain illicit access to data stored in ICT. Cyber-attacks can thereby undermine the accessibility, integrity and confidentiality of the targeted ICT.

Cyber-attacks take place in cyberspace. Cyberspace is not the same as the internet, but the term is often used as a reference to objects and identities on the internet. For example, a website can metaphorically be said only to exist in cyberspace. Similarly, actions undertaken via the internet can be said to unfold in cyberspace rather than at the physical locations of the involved persons, computers, servers, etc. Thus, in a cyber-attack, the distance between the attacker and the target does not play a decisive part.

Cyber-attacks can be carried out by various methods. Among those most frequently used are:

- Hacking, in which the attackers break into IT systems by circumventing passwords, firewalls and other IT security.
- Malware (malicious software), e.g. viruses, worms, trojan horses and spyware, which infects and spreads among computers.
- DDoS (Distributed Denial of Service) attacks, which put ICT systems out of action through massive overloading. The attack is often carried out via so-called botnets, i.e. a virtual network of a large number of computers which are infected with malware and being misused without the owners' knowledge.
- Phishing, which is fraudulent emails intended to trick people into divulging confidential information.
- Defacement, in which websites are illegally taken over and altered.

Perpetrators of cyber-attacks can range from single individuals over small groups and informal networks to states. However, what most attacks have in common is that their complexity usually makes it hard to deduce with certainty who is behind them. The victims of cyber-attacks likewise represent a broad spectrum, from individuals to businesses, public authorities, governments, international organisations, financial markets, etc. In some cases, specific targets are carefully singled out, in other cases, targets are randomly hit.

The motives behind cyber-attacks are correspondingly wide-ranging, but can typically be categorised as having to do with either money, prestige or politics. Cyber-attacks can thus be committed as property crime (e.g. simple theft or industrial espionage), as demonstrations of the attackers' technical proficiency, or on political grounds. An example of politically motivated attacks is international hacktivism (activism through hacking). One of the most notorious networks of hacktivist at present is Anonymous, which, among other causes, campaigns against censorship and for anonymity and file-sharing on the internet. Anonymous has, for example, been responsible for cyber-attacks against Mastercard in 2010; against Swedish authorities' websites in 2010-2012, partly because of a case regarding Wikileaks founder Julian Assange; and against Israeli authorities in November 2012, after Israel threatened to cut off telecommunications to Gaza.

The variety of possible attackers, targets, methods and motives is also illustrated by the dissemination of terms such as cyber-crime, cyber-sabotage, cyber-activism, cyber-espionage, cyber-terror and cyber-war.

To counter cyber-attacks in Denmark, the government established a new Centre for Cyber-Security as part of the Danish Defence Intelligence Service at the end of 2012. The centre is the national authority for ICT security and has three principal tasks: to help protect Denmark against threats in cyberspace; to contribute to a sound and robust ICT infrastructure in Denmark; and to warn of, protect against and combat attacks in cyberspace. Among the centre's areas of responsibility are information security and preparedness in the telecommunications sector and running the state warning system for internet threats, called GovCERT (Government Computer Emergency Response Team). GovCERT was established in 2009.

Possible consequences

Cyber-attacks is not a new phenomena, but cyber-attacks can have larger consequences today; partly because modern society steadily becomes more dependent on ICT; partly because an increasing amount of ICT use takes place in interconnected networks with direct or indirect connections to the internet. A higher degree of integration means greater complexity and thus also more potential vulnerabilities to cyber-attacks.

Cyber-attacks can first and foremost entail consequences for information security and intellectual property rights. They can result in e.g. ICT systems becoming unstable or breaking down (compromised accessibility); changes in data during storage or transport so that the content is no longer genuine or accurate (compromised integrity); or in unauthorised persons becoming able to read protected information, e.g. personnel files, patented knowledge, trade secrets or political negotiation strategies (compromised confidentiality).

Likewise, cyber-attacks can inflict financial losses; partly in the form of expenditure on re-establishing ICT systems and restoring data in the aftermath of attacks; partly in the case of economic crime where valuables are stolen; and partly if attacks result in loss of reputation, of customers and ultimately of income. It is estimated that businesses worldwide lose billions of dollars each year due to cyber-attacks, but the total cost is unknown.

Cyber-attacks have, in the forms witnessed so far, not directly cost human lives. However, cyber-attacks can potentially threaten a range of critical societal functions, and thus entail indirect consequences for life, health and well-being. As such, cyber-attacks are deemed capable of leading to accidents or other situations which, in addition to material damage, endangers people either deliberately or as unintended side-effects. This might happen if, for example, cyber-attacks interfere with vital ICT systems used by the police, rescue services and emergency health services, or with certain SCADA (Supervisory Control and Data Acquisition) systems used for traffic control, energy supply, industrial processes involving dangerous substances, etc.

Past occurrences

Denmark regularly experiences attempts at penetration of the IT and telecommunications infrastructure, but the Centre for Cyber-Security has not yet witnessed cyber-attacks that to any great extent have harmed or hindered the use of this infrastructure or connected physical infrastructure. On a number of occasions, however, Danish businesses, authorities and other organisations have been subjected to extraordinarily disruptive and harmful cyber-attacks.

For instance, the Danish Ministry of Business and Growth suffered a relatively advanced attack in April 2012. The perpetrators of this attack sought to generate an overview of the infrastructure behind the ministry's various sites, to access usernames and passwords, and to access sites, which themselves offer further access to other government departments and agencies. In order to stop and deal with the attack, the Ministry of Business and Growth had to shut down a whole range of IT systems, which meant that employees in the department and several agencies could not, among other things, use e-mail or the intranet for a period.[11]

At the international level, the computer worm Stuxnet in the summer of 2010 set a new standard for how destructive cyber-attacks can be, and it has been described as the first known actual cyber-attack against critical industrial infrastructure. The worm infected thousands of computers on industrial premises, and was particularly sophisticated in that it not only stole information but specifically targeted SCADA systems by exploiting loopholes in the operating systems. Stuxnet was apparently directed against the Iranian nuclear power industry, and penetrated Iran's Natanz complex, which contains about 5,000 centrifuges for enriching uranium. Here, the worm was specially designed to overload the centrifuges by shifting their speed up and down, and it reportedly caused several hundred of the centrifuges to collapse.

Possible trends

Recent years have seen a growing trend towards the use of the internet for espionage against Denmark or to inflict damage on Danish websites and servers. The Danish Defence Intelligence Service, for instance, estimates in its intelligence-based risk assessment of October 2012 that the threat from states, groups and individuals in cyberspace poses a general security risk to Danish society, and that the trend is for the most serious threats to Denmark in cyberspace to come from foreign powers using the internet to spy and steal Danish intellectual property, e.g. patented knowledge, research findings and trade secrets. The assessment is elaborated in the Centre for Cyber-Security's threat assessment of January 2013, which can be found on cfcs.dk. Similarly, the Danish Security and Intelligence Service (PET) has declared that cyber-espionage constitutes a threat to Denmark. PET further assesses, that extreme left-wing groups, among others, will continue to be able to resort to hacking and attacks on IT systems as part of their extremist activities, and that these attacks can also be attractive for individuals without any formal links to extremist groups.

More generally, developments show that cyber-attacks are becoming steadily more rewarding, more sophisticated, more frequent and more precisely targeted. A worrying trend can be witnessed both as regards the modus operandi of the most competent attackers and the availability of tools that less experienced persons can use to commit or participate in cyber-attacks. For instance, the complexity of the coding of certain types of malware indicates that they have been developed by actors with great technical insight and many resources. At the same time, there has been a development in so-called "Exploit as a Service" (EaaS) or "Malware Construction Kits", which is newer form of attack, where tools (kits) to exploit weaknesses in, inter alia, software are obtainable on the black market.

Likewise, a growing trend concerning "social engineering" is expected, which involves manipulating people to disclose usernames and passwords or to install malware. The insider threat from employees who knowingly or unknowingly violate IT security in their workplace will perhaps also increase alongside growing access to information and growing demands for transparency and communication via the internet. The number of machines and equipment connected to the internet rises steeply year by year, more and more information

[11] A number of less serious examples from 2012 are mentioned in the Centre for Cyber-Security's threat assessment published in January 2013, which can be found on cfcs.dk. In early 2012, e.g., a group called UN1M4TR1X0 (Unimatrix Zero), with an avowed link to Anonymous, claimed responsibility for hacks against the news agency Ritzau, the interest organisation IT-Branchen and The State Administration's website. In April 2012, another Danish hacker group, going by the name Unorthodox, claimed responsibility for making the Danish Security and Intelligence Service's website inaccessible through a DDoS attack. This was done as a protest against the use of listening software, which can be installed on a suspect's computer. In July 2012, the trade union 3F's website was made inaccessible for periods as the result of DDoS attacks. A person with an avowed link to Anonymous stated that the attack was a protest against the union's blockade of the Vejlegården restaurant. In November 2012, the Central office of Civil Registration's website, cpr.dk, was attacked by Anonymous, which also claimed to have access to information from an IT company and a waterworks.

appears on the internet rather than on local servers and computers, and employees are to an increasing extent able to access networks, etc. through unsecure mobile devices.

Most cyber-attacks today are related to known weaknesses and deficiencies in security systems. It is assessed, that implementation of simple precautions such as patching and software updating, together with user behaviour, can hinder as much as 80-90 pct of the attacks. On the other hand, the attacks that exploit unrecognized weaknesses will be much harder to protect against. It will be relevant to counter these attacks through more effective preventative measures and the monitoring of networks.

With regard to state actors, especially since the massive cyber-attack against Estonia in 2007[12], there has been a marked development in states' capacity building to become more robust vis-à-vis cyber-attacks. The Centre for Cyber-Security continuously assesses the IT security risk profile for the Danish state's use of the internet and warns the authorities of internet-based incidents and threats, inter alia, on the basis of information on the traffic patterns from the state warning system for internet threats, GovCERT (Government Computer Emergency Response Team). GovCERT has so far chiefly served state authorities, but the legislation on which the warning system is founded also allows its service to be extended to regions and municipalities as well as companies dealing with critical infrastructure.

[12] In 2007, Estonia was the first country subjected to a cyber-attack on a truly massive scale. The three-week long attack affected, inter alia, authorities, emergency services, media, telecommunication companies and the banking sector.

3. Comparison of the incident types

In the five figures below, DEMA seeks to illustrate the national risk profile for 2012 graphically. The positions of the 10 selected incident types within the figures suggests their degree of seriousness – the nearer the centre, the more serious. In this connection, it must be emphasised that the figures are purely an analytical representation based on DEMA's assessments. As such, the positions of the incident types relative to each other in the figures are not rooted in scientifically detailed risk and vulnerability analyses.

The incident types' positions derive primarily from assessments of possible consequences. This is why we have chosen the "target model" rather than a risk matrix, where positioning in fields or on scales requires assessment of both possible consequences and likelihood (frequency or plausibility). Moreover, the positioning is based on "realistic worst case" rather than "worst case" assumptions regarding possible consequences.

Each of the NRP report's 10 sections contained subsections on possible consequences, examples of consequences in Denmark from past occurrences, and possible trends. It is chiefly these descriptions and assessments that determine the incident types' positions in the figures. However, we have to some extent allowed the positioning to be influenced by the consequences of comparable incidents in other European countries. Finally, it must be stressed that the consequence assessments have been undertaken from a purely national perspective. Where appropriate, DEMA encourages readers of the NRP to consider the extent to which their own organisations or areas can be affected by the incident types, and how they have prepared for them.

The first figure depicts an overall assessment. In the other figures, the level of analysis is differentiated by distinguishing between consequences for life, health and well-being; consequences for property and economy; consequences for the environment; and consequences for the availability of critical societal functions.

Figure 1: NRP – Overall consequence assessment

Scale: Inner circle = Critical consequences. Middle circle = Very serious consequences. Outer circle = Serious consequences.

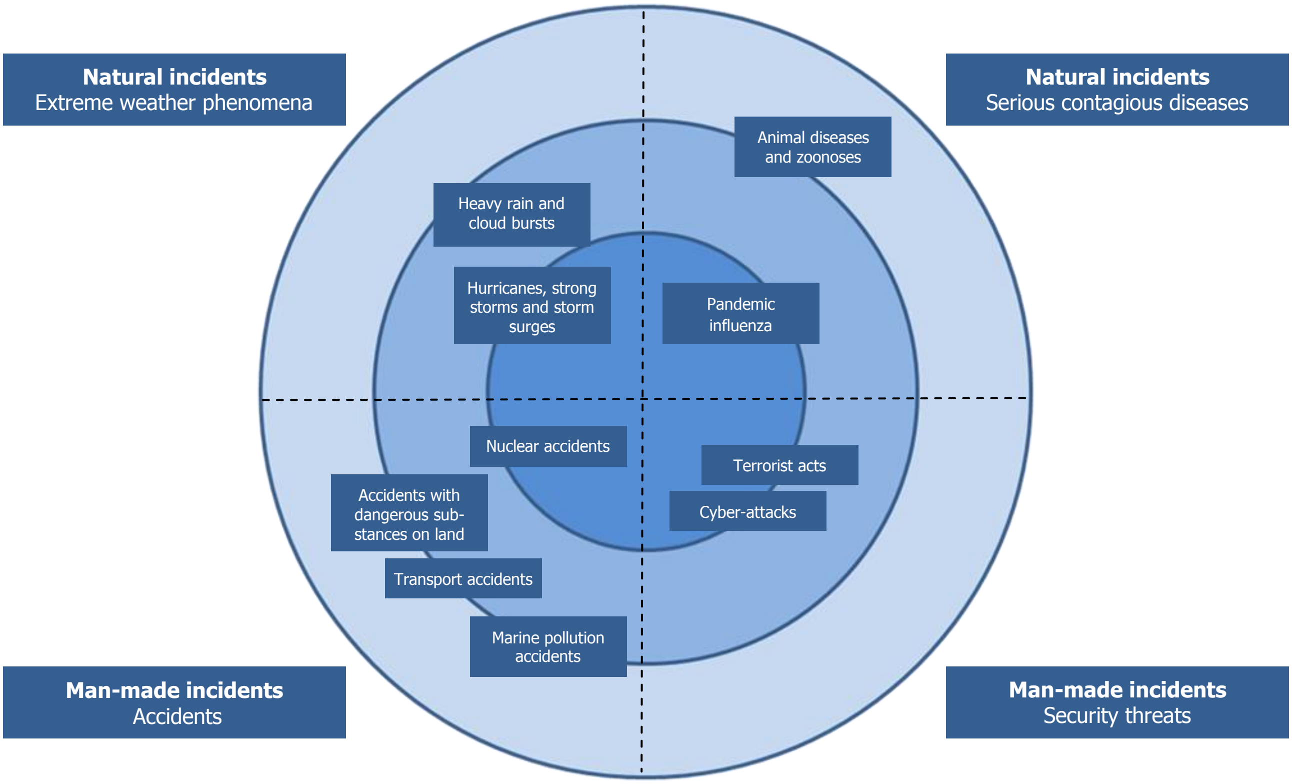

Figure 2: NRP – Consequences for life, health and well-being

Scale: Inner circle = Critical consequences. Middle circle = Very serious consequences. Outer circle = Serious consequences.
Parameters: Numbers of dead, injured, sick, infected/contaminated and prevalence of anxiety/insecurity/fear.

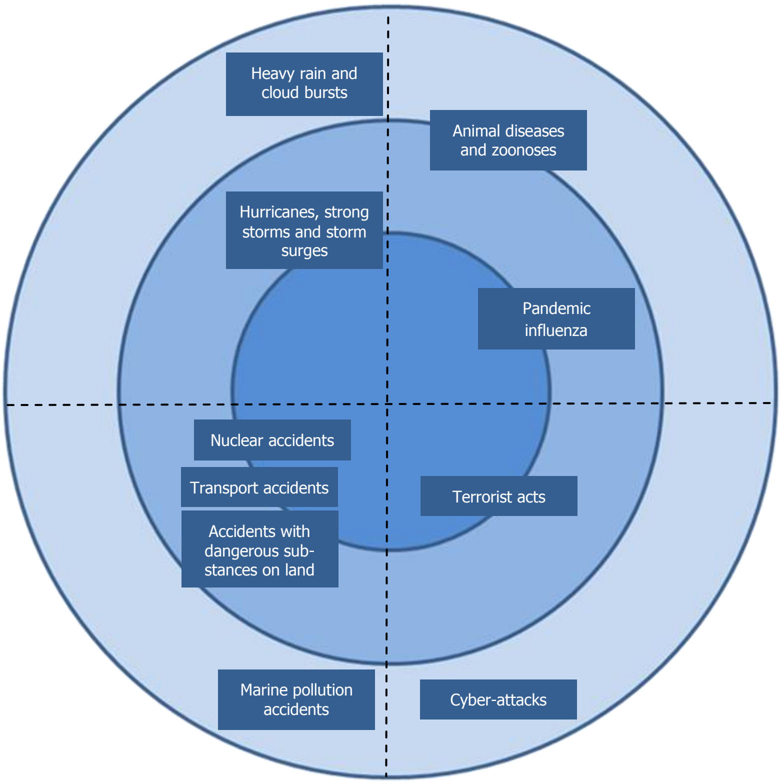

Figure 3: NRP – Consequences for property and economy

Scale: Inner circle = Critical consequences. Middle circle = Very serious consequences. Outer circle = Serious consequences.
Parameters: Material destruction, financial losses, loss of intellectual property rights, destruction/loss of cultural heritage.

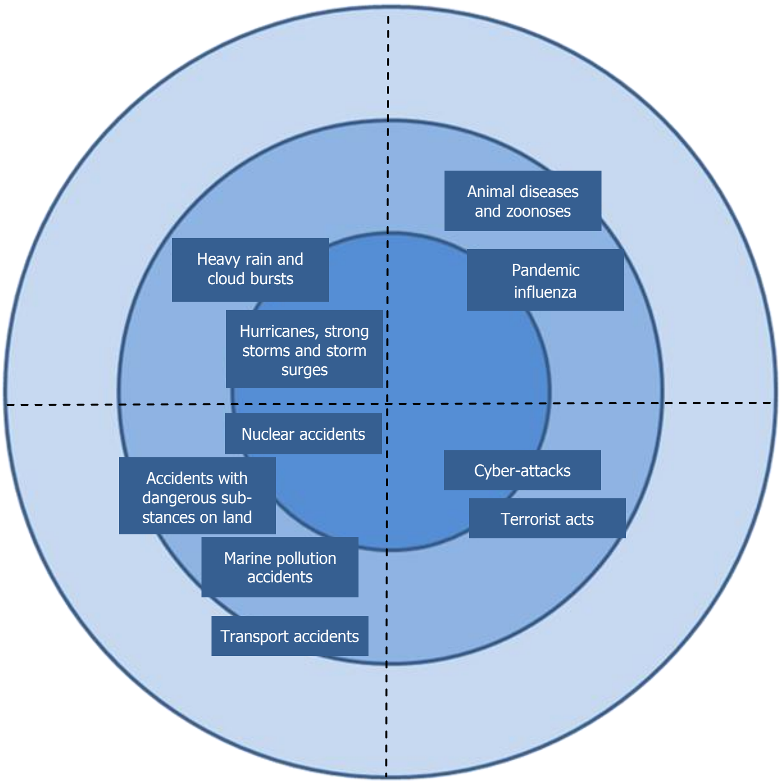

Figure 4: NRP – Consequences for the environment

Scale: Inner circle = Critical consequences. Middle circle = Very serious consequences. Outer circle = Serious consequences.
Parameters: Pollution of land environment, pollution of aquatic environment, harm to animal life, harm to plant life.

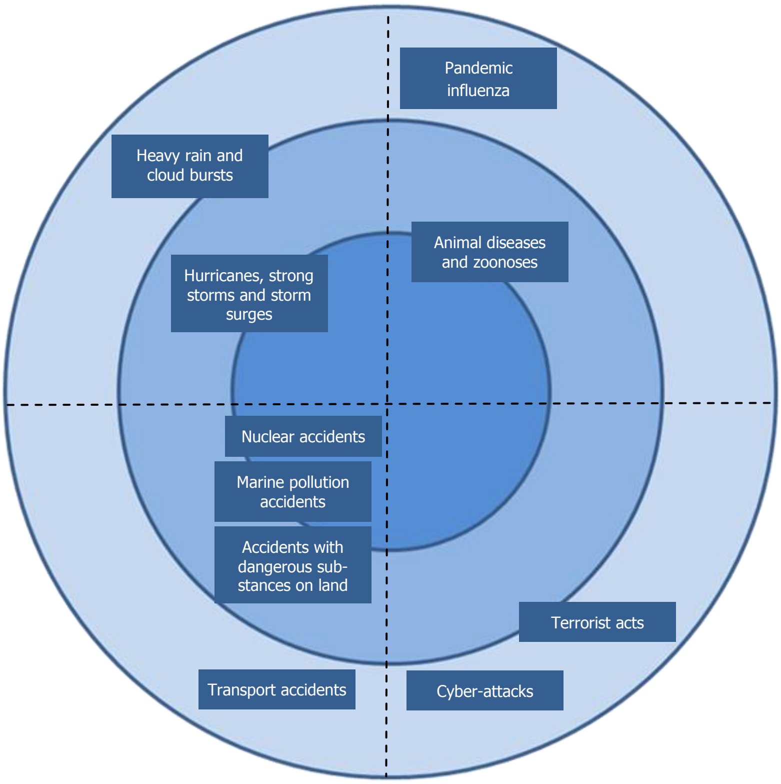

Figure 5: NRP – Consequences for the availability of critical societal functions

Scale: Inner circle = Critical consequences. Middle circle = Very serious consequences. Outer circle = Serious consequences.
Parameters: Breakdown of or extreme pressure on the availability of critical societal functions (examples in table on page 7).