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Is There Enough Power? Swedish Risk Governance and Emergency Response Planning in Case of a Power Shortage

Christine Große
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SNS

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SNS
Box 5629, SE-114 86 Stockholm
Phone: 08-507 025 00
info@sns.se www.sns.se

SNS – the Center for Business and Policy Studies, is an independent, non-profit organization founded in 1948 that aims to be Sweden's leading platform for objective debate and knowledge-sharing among decision-makers on key societal issues. SNS brings together representatives from the business community, public sector, academia, and politics. SNS takes no positions on policy issues, which supports its bridge-building role. Members include companies, public authorities, and organizations.

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Foreword

A RELIABLE SUPPLY of electricity is essential for many societal functions. But there are cases when enough electricity can not be provided to meet demand. To maintain the balance of the power grid system a last resort is to disconnect consumers from the electricity system. When and how such a manual disconnection takes place is based on a national planning system, coined STYREL. This process is significant to enable a prioritisation of electricity consumers and ensure that vital societal functions are provided electricity when a manual disconnection is unavoidable.

In this report, Pär M. Olausson, associate professor of political science and Christine Große, assistant professor of information systems, both active in Risk & Crisis Research Centre at Mid-Sweden University, provide a thorough review of the national planning approach for mitigating power shortages in Sweden. They describe the responsibility of actors involved in the process, how critical electricity users are identified and prioritised, and provide guidance on how to improve the planning process.

The report is part of SNS research program »Energy systems of the future«. The project aims to provide knowledge regarding how the future energy system should be designed to meet the demands of our climate targets while at the same time offering a secure supply of energy.

The project has been made possible through funding from a reference group that is following the research program. The reference group consists of E.ON, Ellevio, Fortum, Göteborg Energi, Holmen, Installatörsföretagen, Kraftringen, Lantmännen, Piteå Municipality, SCA, Scania, Skandia, SSAB, Stockholm Exergi, Svenska kraftnät,

Swedish Energy Agency, Swedish Energy Markets Inspectorate, Swedish Ministry of Finance, Swedish Ministry of Infrastructure, Swedish Ministry of the Environment, Swedish Property Federation, Swedish Society for Nature Conservation, Swedish Transport Administration, Uniper, and Vattenfall. Robert Lundmark, professor in economics at Luleå University of Technology, is the representative of the SNS Scientific Council in the reference group and Jonas Eliasson, director of transport accessibility at Trafikverket, is the group's chairman. The authors received valuable input and comments on earlier drafts of the report from the members of the reference group.

At an academic seminar, Fredrik Bynander, associate professor and director of the Centre for societal security at Swedish defence university, provided constructive comments on the report.

The authors are solely responsible for the analysis, conclusion, and policy advice presented in the report. SNS as an organization does not take a position on any of the perspectives offered by the review. The mission of SNS is to initiate and present research-based analyses of issues of importance for society.

Stockholm, October 2022

Charlotte Paulie
Research Director, SNS

Sammanfattning

DET MODERNA SAMHÄLLET är i stor utsträckning beroende av elektricitet och en trygg elförsörjning är viktig för såväl hushåll och företag som för offentlig verksamhet. Den pågående elektrifieringen skapar en allt högre efterfrågan på elektricitet, vilket kan leda till perioder av elbrist där allas behov av el inte kan tillgodoses samtidigt. För att säkra elförsörjningen till samhällsviktiga funktioner i en situation av elbrist, det vill säga där efterfrågan på elektricitet är större än utbudet vid en given tidpunkt eller i ett givet geografiskt område, har Energimyndigheten tillsammans med Myndigheten för samhällsskydd och beredskap (MSB), Svenska kraftnät och Energimarknadsinspektionen tagit fram ett planeringssystem under namnet STYREL – Styrning av el till prioriterade elanvändare vid kortvarig elbrist.

Syftet med denna rapport är att ge en bakgrund till vad STYREL är, hur det kom till samt vilka tekniska och samhälleliga aspekter som finns med i planeringssystemet. Vidare diskuteras de aktörer som är involverade, hur de förhåller sig till varandra och vilken roll de har i utvecklingen, implementeringen och användningen av systemet. Slutligen diskuteras utmaningarna kring STYREL och hur dessa hanteras inom ramen för det svenska risk- och krishanteringssystemet.

Beskrivning av STYREL

STYREL är ett exempel på flernivåstyrning och kan förstås utifrån teoretiska begrepp som governance, riskstyrning, anpassningsförmåga och resiliens. Processen syftar till att skydda kritisk infrastruktur (även kallad samhällsviktig verksamhet) och inkluderar alla administrativa nivåer i samhället från kommuner och regioner till centrala myndigheter. Som stöd i planeringsprocessen tillhandahåller Energimyndigheten en handbok och tabellmallar.

Planeringen genomförs i sju steg:

1. De nationella myndigheterna identifierar och prioriterar den kritiska infrastrukturen inom deras ansvarsområden. Därefter skickas en lista med de nationellt prioriterade objekten till ansvarig länsstyrelse.
2. Länsstyrelsen delar upp objekten och skickar ut respektive del till ansvarig kommun.
3. Kommunerna gör därefter en egen inventering av lokala samhällsviktiga objekt och prioriterar dem enligt en åttagradig skala.
4. Kommunen begär därefter in uppgifter från lokala elnätsbolag om längs vilka elledningar de identifierade objekten ligger.
5. Kommunen listar sedan elledningarna i prioriteringsordning. Varje kommun uppmuntras även att granska listan för att säkerställa att ordningen återspeglar den önskade prioriteringen.
6. Listorna över de prioriterade elledningarna skickas till länsstyrelsen som sammanställer dem för länet. Länsstyrelsen gör en avvägning för att lösa eventuella konflikter mellan elledningar som korsar kommun- eller regiongränser och bestämmer slutligen rangordningen av elledningarna.
7. Länsstyrelsen skickar därefter in ett slutdokument med rangordningen av de lokala elledningarna i regionen till Svenska kraftnät och de ansvariga elnätsoperatörerna. Utifrån de inskickade prioriteringarna planerar elnätsoperatörerna för en manuell förbrukningsfrånkoppling (MFK) inom sitt ansvarsområde baserat på resultat av STYREL-planeringen. Slutligen meddelar de lokala elnätsoperatörerna när deras MFK-planering är klar (utan att något underlag skickas) till Svenska kraftnät.

Utmaningar för STYREL

Rapporten bygger på ett treårigt forskningsprojekt som genomfördes vid Mittuniversitetet mellan åren 2015 och 2018, »Från myndighet till medborgare och tillbaka: En studie om samverkan och kommunikation inom ramen för STYREL«. Inom ramen för projektet genomfördes intervjustudier med berörda aktörer där det påvisade flera brister i

STYREL-systemet. Det rörde sig främst om kopplingen till det svenska krishanteringssystemet, identifieringen och prioriteringen av kritisk infrastruktur samt användningen av den slutliga prioriterings- eller rankningslistan.

1. HUR RELATERAR STYREL TILL ÖVRIG KRISHANTERING I SAMHÄLLET?

För det första framkom det problem kring hur STYREL relaterar till det övriga krishanteringssystemet utifrån integration, resurser och riktlinjer. Så som STYREL är utformat idag ligger det utanför det ordinarie arbetet inom det svenska krishanteringssystemet, främst vad gäller det kontinuerliga arbetet med risk- och sårbarhetsanalyser. Flera av de aktörer som ingår i studien har påpekat detta när de har intervjuats. Enligt dessa skulle det ge stora fördelar om STYREL tydligare kunde integreras i den övriga krishanteringen något som är svårt i den nuvarande utformningen av systemet. Andra problem är de resurser som behövs för att genomföra STYREL. Hittills har STYREL genomförts vid tva tillfällen: 2010–2011 och 2014–2015. En tredje omgång var planerad till 2019–2021, men denna sköts upp på grund av pandemin. Den långa tiden efter den andra planeringsomgången riskerar att medföra att det organisatoriska minnet mellan omgångarna blir begränsat.

I flera kommuner ansvarade enskilda handläggare för arbetet med STYREL, vilket har gjort det extra sårbart. Kunskapen om vad som låg bakom de ursprungliga prioriteringarna blir därmed också begränsat. Tillsammans med en ofta bristfällig dokumentation leder det till att kunskapen mellan omgångarna helt riskerar att försvinna om de ansvariga inom kommunerna byts ut mellan omgångarna, något som visade sig vara fallet i flera av de undersökta kommunerna och länsstyrelserna. Mer än hälften av de ansvariga handläggarna vid länsstyrelserna från den första planeringsomgången hade ersatts av andra handläggare nästa omgång. I de kommuner som deltog i studien hade 40 procent av handläggarna i den andra omgången inte deltagit i den första.

Likartade förhållanden syns hos i princip alla aktörer i processen. Den uppenbara brist på kunskap och kontinuitet som detta medför har sannolikt påverkat förmågan att samordna arbetet och bearbeta information. Därtill beskrevs i flera fall hur tidigare prioriteringar kvarstod utan någon mer ingående analys mellan omgångarna, ett slags kopiera-och-klistra-i-förfarande.

Vidare finns problem med riktlinjerna för planeringen. STYREL inkluderar främst offentliga aktörer på lokal, regional och nationell nivå, bortsett från företrädarna för de lokala elnätsbolagen. Detta gör i sin tur att viktig kunskap kan gå förlorad i planeringen av samhällsviktig verksamhet, eftersom den privata sektorn ansvarar för utveckling, underhåll och drift av stora delar av samhällets viktiga verksamheter. En anledning till att planeringen varit begränsad till offentlig verksamhet är att ansvaret för att identifiera och prioritera samhällsviktig verksamhet ofta har legat hos en enskild tjänsteperson. Slutligen är kontakten mellan de olika nivåerna i planeringssystemet begränsad, vilket riskerar att leda till brister i förtroendet och tilliten mellan aktörerna. Även om planeringssystemet involverar många aktörer, saknas till stor del aktörer från privat sektor och icke-statliga organisationer. Analysen visar på oklarheter i flera steg i processen, till exempel vad gäller informationsvägar, förväntade insatser och ansvar. Detta har bland annat resulterat i långdragna processer, informationsbrister och opersonlig interaktion, vilket i flera fall försvårat samarbetet och skadat det ömsesidiga förtroendet och respekten mellan aktörerna. Planeringssystemets utformning förhindrar i vissa fall transparensen, vilket i sin tur försämrar utvärderingsmöjligheterna. Vidare gör detta att återkopplingen mellan de olika stegen i planeringen är i det närmaste obefintlig.

2. IDENTIFIERING OCH PRIORITERING

För det andra finns det utmaningar med att identifiera och prioritera samhällsviktig verksamhet samt svårigheter att uppnå en gemensam policy kring vad som ska klassas som samhällsviktig verksamhet och vilken rankning enskilda verksamheter bör ha. Även här är det ett problem att STYREL i flera kommuner endast hanterats av en enskild tjänsteperson. Detta skapar, som nämnts ovan, problem med kontinuiteten inom planeringssystemet, men även kring besluten om vad som är samhällsviktig verksamhet och vilka objekt som ska prioriteras framför andra. Här visar den genomförda intervjustudien bland annat på behovet av en mer omfattande dokumentation och tydligare överlämning till efterträdaren. Vidare behövs en dialog om bedömningskriterier och samordning på regional och nationell nivå.

Dessutom är arbetet med identifiering och prioritering omfattande och tidskrävande. Arbetsbördan blir ohanterlig över tid när endast en eller ett par handläggare ansvarar för detta arbete. Inför den andra omgången kom därför analysen av vad som är samhällsviktiga objekt att bli begränsad, och i flera fall kopierades resultatet från den tidigare omgången. Detta medförde att liknande objekt rankades likadant och ofta på samma sätt som i den tidigare omgången utan någon analys av dess eventuellt förändrade roll i samhället eller att avgöra om alla objekt av samma typ (exempelvis alla förskolor) verkligen lika viktiga i en bristsituation.

Till utmaningen bidrar en begränsad förståelse för varandra när det gäller både den dagliga verksamheten och aktiviteterna under planeringsprocessen. Därför efterfrågar de intervjuade aktörerna en mer utvecklad samverkan mellan aktörerna i planeringssystemet så att inte prioriteringen och rankningen av identifierade objekt blir för olika mellan aktörerna. De intervjuade pekar på svårigheter att väga viktiga samhällstjänster mot varandra. Detta ökar behovet av gemensamma regler för att bedriva uppdraget likvärdigt i hela landet. Slutligen upplevs prioritetsklass I som alltför bred. Även om STYREL-handboken stipulerar en kumulerad regional rangordning för alla kraftledningar, saknas direktiv både för utförandet av viktningen av kritisk infrastruktur mellan intressen på kommunal, regional och nationell nivå och sammanvägningen av rankade elledningar på regional och överregional nivå.

3. IMPLEMENTERINGEN AV STYREL

För det tredje finns det utmaningar kring nyttjandet av den framtagna planen i exempelvis den efterföljande beredskaps- och kontinuitetsplaneringen samt kring krishanterings- och katastrofinsatser för en resilient samhällssäkerhet.

De slutliga prioritets- och rankningslistor som sammanställs på kommunal nivå och skickas vidare till länsstyrelserna saknar information om vilka objekt som återfinns längs de prioriterade elledningarna – den enda information som finns med är vilken rankning den enskilda elledningen har. När listorna ska sammanställas av respektive länsstyrelse saknas därför viktig information. Länsstyrelsen har i detta läge endast att lita på att kommunerna rankat elledningarna på liknande sätt. Detta gäller även den sammanställning som sänds över till elnätsbolagen: de samhällsviktiga objekten finns inte med, endast en rankning av elledningar.

Vidare finns problem med att elledningar ändrar beteckning, förnyas eller dras om på grund av kontinuerlig utveckling av elnätet. Så snart en prioriterad elledning ändrats finns risk att den information som finns om elledningar med samhällsviktiga verksamheter blir föråldrad, särskilt mot bakgrund av den tid som förflutit mellan den senaste planeringsomgången och den tilltänkta. Detta försvårar för kommunerna att ta sitt ansvar vid en kris. Kommunen kan inte vara säker på vare sig att den elledning som en gång prioriterades behållit prioriteringen genom hela planeringssystemet eller att den fortsatt förser det aktuella objektet med el.

Förslag till vidareutveckling av STYREL

Som Mittuniversitetets intervjustudie från 2015–2018 upprepade gånger visat finns det ett stort behov av att vidareutveckla STYREL för att kunna stärka samhällets säkerhet och motståndskraft. Särskild uppmärksamhet bör ägnas åt cybersäkerhet som inte bara avser konfidentiell information utan även integritet och tillgänglighet för behöriga användare vid behov. Interorganisatorisk informationshantering mellan aktörer (när det gäller STYREL mellan lokala, regionala och nationella aktörer) är särskilt relevant för att kunna skydda kritisk infrastruktur, där informationssäkerhet och informationsdelning är viktiga men ibland motstridiga aspekter. STYREL anses av samtliga intervjuade aktörer vara ett viktigt planeringssystem för att kunna upprätthålla en rad samhällsviktiga funktioner när det är elbrist. Systemet fyller en viktig roll i det svenska krishanteringssystemet och kan även bli betydelsefullt för det planerade svenska medlemskapet i Nato. Detta förutsätter dock att de utmaningar som finns med STYREL hanteras för att få ett väl fungerande system som är integrerat med övriga delar av det svenska krishanteringssystemet.

Mot bakgrund av de brister vi har identifierat föreslår vi följande åtgärder:

1. Relatera STYREL tydligare till det svenska krishanteringssystemet. Till exempel borde STYREL kunna kopplas tydligare till risk och sårbarhetsanalyserna för att skapa synergieffekter och undvika dubbelarbete för inblandade aktörer.
2. Skapa förutsättningar för att hantera problem med kontinuitet över tid, för att undvika att kunskap och kompetens går förlorad mellan omgångarna.

3. Genomför en översyn av vilka aktörer som involveras i planeringsprocessen och skapa ett ökat intresse och engagemang hos privata aktörer, särskilt gällande inventeringen av samhällsviktig verksamhet, samt möjliggör och främja ökad samverkan och nätverksstyrning.
4. Utveckla förutsättningar för ett utökat informationsutbyte mellan aktörerna, utifrån såväl informationssäkerhet och sekretess, som riktighet och tillgänglighet av information både under planeringen och mellan planeringsomgångarna.
5. Analysera möjligheter och former för ett utvecklat samarbete mellan elnätsoperatörer kring planering och effektuering av MFK.
6. Genomför en översyn av prioriteringslistan för att skapa tydligare instruktioner och bättre förståelse för prioriteringen av samhällsviktiga verksamheter. Detta bör göras i samverkan med ingående aktörer.
7. Etablera en struktur och möjlighet för regelbunden vidareutveckling av STYREL. Samhället är i ständig förändring och utveckling, vilket medför att även STYREL kontinuerligt behöver revideras för att anpassas till nya utmaningar, till exempel kring utvecklingen av det civila försvaret samt anpassning inför Natomedlemskapet.

Introduction

AFTER OUTLINING THE PURPOSE of this book, this chapter discusses the Swedish context of power supply and a current approach for mitigating power-shortage risks – including negative effects on critical infrastructures and society – called STYREL. It also provides a brief overview of theoretical key concepts regarding systems, critical infrastructure, risk governance, crisis management and multi-level planning. At the end, it presents the methods of policy analysis applied during the research project and the outline of this book.

Purpose and Context

This book is intended for readers wanting to know more about risk governance and crisis management in the Swedish context in general and in particular with regard to a large-scale, multi-level and long-term planning process for addressing the risk of power shortages in society. The text is intended for audiences concerned with societal security and civil protection, such as students, policy and decision-makers in the public and private sectors, security officials at municipalities, companies, national agencies and authorities as well as the interested public.

It also aims to expand our understanding of challenges related to societal security and efforts in public-private collaborations to ensure the proper functionality of critical infrastructures providing the basis for everyday life and future development in modern societies. To this end, the book analyses a national planning approach for mitigating power shortages in Sweden called STYREL and analyses the context of the planning, the governance network entrusted with decision-making and responsibilities and the utilisation of the resulting plan for critical infrastructure protection in the Swedish crisis management system. The analysis pursues the following questions:

1. What is STYREL and how did it come about? What are the technical and societal contexts?
2. Which actors are involved in STYREL, how do they relate to each other and what is their role in the development, implementation and utilisation of STYREL?
3. Which challenges does STYREL have to contend with and how may these be addressed within the Swedish risk and crisis management system?

The results reveal that some of the challenges in the STYREL approach are exemplary for the Swedish risk and crisis management system in general. In addition, identifying and prioritising critical infrastructures at the local, regional and national levels as well as aggregating local rankings into plans that ultimately match power grid areas represent matters of severe concern. These emergency response plans, which are intended to support decision-making in the event of a power shortage and to mitigate the negative effects of a power shortage on society, have never been employed in a real-life situation. Therefore, the effectuation and usefulness of these plans remain topics of further debate in the context of societal resilience and security.

Electricity is a key resource in the everyday life, business and public operations. Some of these operations become critical if their continuity is crucial during disturbances with regard to the survival and progress of society. Failures in the power supply threaten the safety and security of societies, as they are increasingly dependent on electricity to maintain important functions through critical infrastructures, such as health care, water and food supply, information and communication, financial services, fuel and transportation. Continuous developments in key infrastructures, such as railways and electric cars, are likely to increase our dependency on electricity over time (Cedergren et al. 2015). At the time of writing, a likely scenario for Sweden is that the demand for electricity increases by 100 percent over the next two decades (Energiföretagen Sverige 2019, 2021; IVA 2015; Svenska kraftnät 2019). Such a forecast is primarily driven by the fact that the transport and industrial sectors have to reduce their climate footprint, where a shift from fossil fuels to electricity is seen as contributing to the transformation towards a more sustainable society. This is commonly referred to as part of the energy transition. Apart from the technical challenges, such increased demand might also result in some additional side effects that need to be considered. For example, what happens if the demand increases faster than it can be met? How prepared is society for large-scale power outages? How do we prevent such a situation? The public debate is thus increasingly concerned with electricity shortages that might accompany energy transition processes due to aspects such as hard-to-plan energy production or the rise of electricity-intensive industries. Although thinking of such situations is somewhat frightening, it is crucial to understand the imminent risks related to a power shortage or outage. For instance, the storms named Gudrun, Per, Dagmar and Ivar caused major problems in Sweden, which in some cases lasted for more than a month (Große 2018a, 2018b). Experiences from local power outages in the aftermath of these storms have revealed that actors at municipalities and power grid operators expected households to be prepared; however, households did not recognise this responsibility to establish this kind of preparedness (Palm 2009). In addition, the absence of severe large-scale power shortages or outages in the past has resulted in a lack of experience with such crisis events among people responsible for this type of planning in municipalities (Enander et al. 2015).

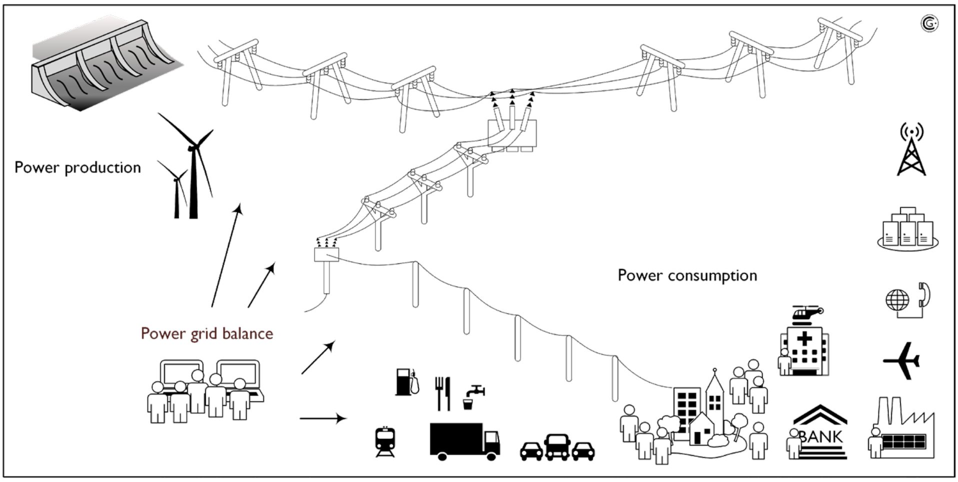
Despite the fact that Sweden exports more electricity than it imports, society is threatened by a lack of electricity or rather a lack of power at a certain place at a certain time. In contrast to a *power outage*, which can be experienced following a major failure in power production or transmission, a *power shortage* typically means that not enough electricity is available at a certain time and location to meet the demand of all consumers. For example, there is a risk of power shortages during a number of hours on a very cold and windless day when demand is high. One reason why a power shortage may occur is that electricity cannot be transferred in sufficient quantities from the areas where it is produced to the areas where it is demanded. This may be because the transmission capacity of the electricity grid is insufficient, which is called *capacity shortage*. A simplified explanation is that the wires become 'full'. To avoid capacity shortages, the entire power grid needs to be suitably dimensioned, from the main grid to the regional and local grids. Today, however, there are some bottlenecks in the Swedish network that limit the ability to transport the input power. Another reason why a power shortage may occur is that domestic production sometimes experiences difficulties covering the current consumption, especially during cold winter months in Sweden or a sudden increase in demand. Such a domestic *production shortage* is generally remedied by importing electricity from neighbouring countries or activating agreed-upon power reserves (Svenska kraftnät 2021a).

Further reasons why a power shortage may occur are related to the dimension of the power grid in Sweden and the great spatial distances between electricity production and consumption. Similar to other critical infrastructures, the power grid is vulnerable to various risk events, such as failures due to aging components, destruction, cyberattacks or severe weather conditions, including storms and floods. Today, a large amount of Swedish power production is located in the northern part of the country, whereas most electricity is consumed in the southern part. However, industrial investments[1] in northern Sweden are currently booming, including several electricity-intensive operations (Region Norrbotten 2020). Taken together, these investments, including those in hydrogen production, are estimated to constitute an increase in electricity demand between 100 and 170 TWh, which corresponds to far more than half of Sweden's current consumption of 140 TWh (Energiföretagen Sverige 2021) and is considered a 'historical major challenge'[2] in terms of maintaining a reliable power supply.

In addition to climate conditions and an increasing risk of extreme weather-related disturbances, there are several challenges in relation to electricity production, transmission and usage. Large portions of the electricity production and electricity network were expanded in the 1960s and 1970s and are still in use today. This, on the one hand,

1. https://northvolt.com/articles/northvolt-equity-june2021/; https://www.hybrit-development.se/; https://www.vindkraftsnyheter.se/20190803/5696/bygger-storsta-vindkraftparken-i-europa; https://www.talgagroup.com/irm/content/graphite.aspx?RID=275; https://www.sunpine.se/pressmeddelanden/sunpines-nya-fabrik-ar-redo-att-leverera/
2. https://www.di.se/nyheter/energifragan-sinkar-satsningarna-kravs-massiv-utbyggnad-historiskt-stor-utmaning/; https://www.dagensps.se/teknikdygnet/norra-sverige-krafttag-kravs-for-att-radda-investeringar/

Figure 1. The system of power production, transmission and consumption.



means that these portions of the network are dimensioned according to the assessments made almost 70 years ago and need to be expanded to meet the needs of today and the future. On the other hand, it means that the grid is aging, which, in turn, entails the risk that something will break or that the grid will simply no longer be able to handle the same load. Moreover, rapid technology developments lead to new demands. One example is the digitalisation of society, which increases our electricity needs, around the clock, all year round. This need is increasing among individuals, in public administration, societal services and industry as well as in new areas such as data centres and server rooms. In addition, the ambition is to shift energy production to more sustainable systems, while at the same time increasing the electrification of society in order to reduce the use of fossil energy sources. The transport sector is just one of all the sectors that will require increased access to electricity. This applies to both freight transport and various kinds of passenger transport. A growing need and dependence on a reliable power supply also increase society's vulnerability to other disruptions, such as the cyberattacks on the energy supply having attracted increasing attention in recent years.

For the electricity system to work, the production and consumption of electricity need to be in balance. In the transmission system (i.e., the power grid), the balance is regulated both automatically and manually through various tools for controlling production and consumption. If automatic measures are not sufficient, a manual disconnection (MFK)[3] represents the last resort for preventing a collapse of the electrical transmission system. When an MFK must be effectuated, the decisions on disconnection should be based on a plan that is produced in advance through preparatory national planning, called STYREL, which is a Swedish acronym for *STEERing ELelectricity to prioritised electricity users in the event of a power shortage*. The major blackout in southern Sweden in September 2003 may have been the catalyst for developing the national STYREL planning approach (Große 2018b).

Since 2004, the Swedish Energy Agency (SEA) is entrusted with developing and managing STYREL, in which three additional national agencies also have a clear responsibility: the national power grid operator Svenska kraftnät, the Swedish Civil Contingencies Agency (MSB) and the Swedish Energy Markets Inspectorate. STYREL was developed between 2004 and 2011, and it involves a large system of actors in society:

› all Swedish 290 municipalities
› all Swedish 21 regions and 21 county administrative boards (CABS)
› some 160 power grid operators,
› some 100 authorities
› an unknown number of private companies

Apart from a pilot implementation in 2009, the planning process was conducted on two occasions: in 2010–2011 and 2014–15. Following the legally stipulated four-year interval, the third round was scheduled to run between 2019 and 2021. However, due to the Covid-19 pandemic, the process has been postponed twice by one year until 2022. The plan was to proceed with STYREL 3 in 2022–23 and to start with STYREL 4 in 2023 to make up for the lost time. However, due to the tense security situation as a result of the invasion of Ukraine, the proceedings were

3. MFK is the Swedish acronym for manual load shedding [manuell förbrukningsfrånkoppling].

changed to allow municipalities to choose to what extent STYREL 3 and 4 will be conducted.[4] Chapter 3 presents more details about the actors and activities in the planning process.

Outline of the Book

As outlined above, this book aims to expand our understanding of challenges related to societal security and efforts of public-private collaborations to ensure the proper functioning of critical infrastructures. This introduction proceeds with presenting an overview of the theoretical and empirical underpinnings of this book, whereas the following chapters provide information concerning Sweden's response planning with regard to disturbances in the electricity supply. The insights discussed contribute to the interested reader gaining an increased understanding of the complex relationships between the electricity supply, critical infrastructures and the societally important services they provide as well as the intertwined risk and crisis management system in the public sphere of societal security.

Chapter 2 provides an in-depth background on electricity supply, including a few technical requirements and conditions as well as challenges accompanying current trends in society. In addition, it presents the Swedish crisis management system, including perspectives from the national, regional and local levels. It also provides a brief international overview of similar planning systems.

Chapter 3 discusses the questions of what STYREL is and how it came about. What are the technical and societal contexts? It begins by sorting out the progress of the planning process from the government investigation in 1995 to the development of STYREL and the pilot planning in 2009. It then details the STYREL process and the approach for identifying and prioritising electricity-dependent societal functions and activities, as well as the method for developing a weighted list forming the basis for decision to be used in the MFK planning carried out by power grid companies. The differences between the various planning rounds implemented so far are also highlighted.

Chapter 4 pursues the question of who are the relevant actors in

4. https://trk.idrelay.com/2930/arc?q=b72-8378&c=bf296db3f9

STYREL, how do they relate to each other and what is their role in the development, implementation and use of STYREL? It especially emphasises aspects such as the actors' different goals and purposes, the decision support available and the reinterpretation processes occurring during the process. In addition, it illustrates the complexity of the planning task, which prompts emergent effects, such as the ones observable in the interaction between the actors. The chapter concludes with reflections on collaborations to shed light on conditions, forms and potential.

Chapter 5 explores the question of which challenges STYREL has to contend with and how these may be addressed within the Swedish risk and crisis management system. To this end, the chapter discusses the potential for improvements in the STYREL approach and looks ahead within STYREL, society's risk governance, the overall Swedish crisis management system and the current challenges for societal security that may be recognised.

Theoretical Foundation

This section describes the theoretical perspective having framed this analysis of the STYREL approach. It includes the key concepts of system, critical infrastructure and governance, as well as their relationship to the context of risk governance, crisis management and multi-level planning.

WHAT IS A SYSTEM?

Basically, a system, such as critical infrastructure, consists of three key elements – components, their interactions and an environment. Systems are often characterised by their properties or a purpose-giving process.

A system-of-systems evolves if systems interact with other systems to achieve a common purpose (Große 2020). For example, the power supply system consists not only of different power production systems and the transmission system but also of the multitude of consumers that make up the consumption system. This infrastructure system encompasses both the fixed assets of the electrical system and the entire power supply process as well as a variety of regulations.

Definition: System

A *system* is an assemblage of *components* with properties that, through certain *interaction* within an *environment*, fulfil a common (i.e., critical) *process*. In this form, a system has properties, can exhibit behaviour and may interact with its environment.

A *process* is a content-related and self-contained sequence of timely and logically consistent events and activities that handles a central, process-characterising object. A process strongly depends on proper functionality of the majority of system components.

To *maintain* a (critical) process, a system must master *adaption*, *emergence* and *entropy*, which necessitates a *control* mechanism.

WHAT IS INFRASTRUCTURE?

The term *infrastructure* stems from the Latin words *infra* (underlying) and *structura* (assemblage). Thus, infrastructure is defined as an underlying basis. The growing interconnectedness of modern societies has increased their dependency on vital functions. If a society depends on the maintained functionality of infrastructure for its survival, well-being and progress, this is viewed as critical infrastructure.

WHAT IS GOVERNANCE?

In political science it is often argued that there has been a shift from a Weberian, top-down, regulatory state (i.e., government) to a more collaborative state involving both public and private actors (i.e., governance) (Talesh 2021). Governance involves decision-making processes and particularly the distribution of public responsibilities across multiple stakeholders, which can interact both as individuals and as participants with mutual interests (Lovan et al. 2016), not only in the context of energy policy. Pierre and Peters (2000) have framed the management of society as a continuum that extends from traditional top-down control to self-organisation and networks. The former is often linked to traditional government while the latter indicates important properties of a governance system. However, whereas the term 'government' clarifies the body that governs society, the term 'governance' obscures the governing actor. In the social sciences, it has thus been questioned whether governance indicates the contraposition (*Gegenbegriff*) or the umbrella term (*genus proximum* or *Oberbegriff*)

Definition: Infrastructure

Infrastructure is perceived as an always existing, long-lasting and *fixed common good* that unites material, building processes and an expression of will. At the same time, it is viewed as an *operative process* of a system-of-systems that, through control of the former, provides essential goods and services for public well-being. The latter is also in need of steering to ensure integration, co-ordination and orchestration of services among the involved systems.

Infrastructure becomes *critical* if the survival, well-being and progress of a society depend on its maintained orchestrated functionality.

Definition: Governance

Governance refers to a collaborative state involving public and private actors in contrast to the Weberian hierarchical state with an exclusive right to public decision-making.

Governance seeks to pursue common, societal concerns located in the field between governmental control and competitive market dynamics as well as the private sphere of citizens.

Governance networks refer to self-organising, inter-organisational networks characterised by interdependence, resource exchange, rules of the game and significant autonomy from the state.

Governance networks are important representations of public-private collaboration systems constituting a steering mechanism of (infrastructure) systems vital for society.

to government (Colebatch 2014; Offe 2008). In addition, practicing decentralised governance as the opposite approach to centralised government has revealed deficiencies, such as dysfunctionality and loss of institutional memory in terms of how things have evolved and even why they evolved (Tingle 2015). The lowest common denominator characterises governance as a departure from traditional ruling towards participative forms of policy-making in which, according to Rhodes (1996), 'self-organizing, interorganizational networks [...] complement markets and hierarchies as governing structures for authoritatively allocating resources and exercising control and co-ordination'. Such networks are further characterised by 'interdependence, resource exchange, rules of the game and significant autonomy from the state' (Rhodes 1997). Thus, governance networks are an important phenomenon in both governance and public policy theory (e.g., Henry 2011; Petridou 2014).

Governance thus involves managing networks, especially since many organisations use networks to achieve their goals, maximise their influence over outcomes or avoid being dependent on other actors. By participating in networks, organisations are able to reduce transaction costs and information asymmetries between actors, which also has a positive effect on legitimacy and the acceptance of public policies (Ahrens & Rudolph 2006).

Network governance is based on the notion of co-operation between actors representing both public and private sectors. Although governance networks are often created and co-ordinated by the state, self-organisation is seen as the ideal steering mechanism for such networks in which actors come together and utilise one another's resources, whereas a resource dependency between the actors occurs if actor A has something that is valuable to actor B and vice versa (Sørensen & Torfing 2005). However, if the development and maintenance of a network is enforced upon the actors, it is important to give them clear instructions regarding the aim of networking, which enables the actors involved to achieve their interrelated goals (Olausson & Nyhlén 2017).

A key aspect of all types of networks is the interest that dominates them, such as professional and economic interests or those of the state. Networks thus vary in terms of both the degree of internal influence and the properties that ultimately characterise the individual nature of a network, which means that networks must be studied empirically to be characterised (Rhodes 1997). The relationships between the actors in a network are often horizontal, but they can also be vertical, as in a municipal organisation (Montin 2006). Studies of governance networks show that mutual trust between the actors is important for both the effectiveness of networks and for the decision-making capability in a network. Despite the importance of trust, there is a striking lack of studies including trust (Edelenbos & Klijn 2007; Klijn 2008; Provan & Kenis 2007). Robins et al. (2011) have studied the Swan-Canning River System in western Australia and emphasise that governance networks do not imply effective governance per se. The actors need to commit themselves to the co-operation and share information among themselves. If there is a lack of trust, then there is a risk that the actors will not engage properly in the co-operation. Such a lack of commitment may include a subsequent risk that the actors withhold information from each other.

Networks may also involve lobbying groups consisting of public and private actors. Johansson (2015) analyses the implications of lobbying networks for public decision-making. Based on a case of risk assessment for a road construction project in western Sweden, Johansson has indicated that the network was successful in overriding procedural expert-based decision-making. In a study of local environmental policy, Gustavsson (2008) has shown that networks enable participants to influence environmental policy at different levels. Networks also serve as nodes for transferring knowledge between the actors. Furthermore, networks also serve as areas where personal contacts are established between the actors (Gustavsson 2008).

The logic of decision-making in governance networks is based on a reflexive rationality, meaning that decisions are made in ongoing negotiations between the actors included. As networks involve interdependencies between the actors, this negotiation process must include solving conflicts between the actors in the network due to different interests and different understandings of the issues that constitute the purpose of the network (see Scharpf 1994; Sørensen & Torfing 2007). This negotiation might not only end in policy decisions but might also have side effects that change the entire policy discourse, including a redefinition of the actors included and the foundation upon which decisions and regulations are based (Sørensen & Torfing 2009).

A lack of compatibility between governance arrangements and democracy is often stressed in the research on governance. This lack is mainly the result of identified challenges in terms of democratic accountability. For example, policy networks often include both public and private actors, several of which are not formally accountable (Papadopoulos 2003; Peters & Pierre 2006; Rhodes 1997).

To govern development and risks and to manage crises in societies, some behavioural aspects and system properties need further consideration, such as adaption, emergence and entropy.

Definition: Complexity

Complexity refers to a collection of system properties:
- Large extent of the system
- The system components that
    - are interconnected
    - are interdependent
    - act autonomously
    - exhibit adaptive behaviours, all of which invoke
- A non-linearity of consequences

Definition: Adaption and Adaptive Capacity

Adaption occurs by learning from individual experiences. Experiences of other group members can profoundly influence individual judgements, thereby inducing further adaption to suit certain circumstances.

Adaptive capacity refers to the extent to which a society is able to respond and adapt to changes, such as climate change, and its willingness to take measures to manage such phenomena.

Definition: Emergence and Resilience

Emergence refers to a set of effects that are spontaneous, uncertain and very difficult to predict. Such effects emerge from adaptions at several levels that induce further interferences back and forth through the system(s) and environment(s). Emergence becomes evident at a system level superordinate to the level at which the adaption manifests itself.

Resilience is a behaviour of a system emerging from its capability to handle its vulnerabilities through adaption, recovery and dedicated change to developing conditions.

Definition: Entropy

Entropy is a measure of how much energy has transformed from *exergy* into *anergy*, meaning the portion of resources unavailable for carrying out purposeful work in a system.

In information theory, entropy is thus considered a measure of uncertainty (i.e., the lack of knowledge in a system).

The entropy of a system increases due to irreversible processes. To lower entropy and obtain a form of restitution of the previous state, a compensation must occur, meaning that exergy (such as new resources in the form of, for instance, energy, knowledge or commitment) must enter, and anergy (such as waste heat, ignorance, frustration or stress) must be dissipated from the system. If not resolved, entropy will cause the termination of a system.

PROPERTIES OF SYSTEMS

The concept of complexity is closely related to systems in a social context. Common criteria for classifying a system (e.g., the power system) as *complex* include interconnectedness, interdependency, autonomous and adaptive behaviour of system components, non-linearity of consequences and the extent of the system (Große 2017b; Holland 2006; Onik et al. 2016). Moreover, this non-linearity of cause and effect due to interconnected subsystems can evoke an emergent system behaviour. Complexity challenges the analysis, modelling and governance of such systems as a multitude of factors can contribute to the problem (Große 2020).

The concept of adaptive capacity dates back to Darwin and the theories of evolution (Engle 2011). Complex adaptive systems, such as critical infrastructures, consist of interconnected and autonomous agents that can act in parallel and adapt to interactions and environmental conditions (Hokstad et al. 2012; Holland 2006). In social sciences, the concept was first used to describe leadership and organisational success in terms of the ability to adjust to unforeseen issues and unpredictable events (Engle 2011). In addition, adaptive capacity has been related to climate change and the readiness of society to alter behavioural patterns to tackle interrelated problems and issues (Khailani & Perera 2013; Richmond & Sovacool 2012).

This concept can thus also be applied to the energy supply in society when focusing on society's vulnerabilities and the impact of climate change on the energy sector as well as society's possibilities to handle the evolving situation (Giannakopoulos et al. 2016). Adaptive capacity and resilience are closely connected; however, there are differences in meaning that might be linked to the type of system under consideration. One particular concern is how adaption and resilience relate to each other. It is important to understand that adaption and resilience refer to different system levels. Nevertheless, adaptive capacity is often seen as an important component of resilience, which easily gives a false impression of a linear relationship instead of a dynamic and non-linear loop of causes and consequences. Adaption within the system and its extent can lead to non-linear consequences that may even be recognised as emergent behaviour and unpredictable outcomes. Expressions of such emergent behaviours include resilience or evolution. In crisis situations, a system's emergent behaviour may become evident through, for example, the appearance of spontaneous volunteers. Such actors that are not sufficiently recognised in emergency response plans are also collectively referred to as emergent actors.

The word resilience derives from the Latin word *resilio*, which means to jump back (Klein et al. 2003). This concept is often defined as the ability to return to an original status after a temporary disruption (see, for example, Wildavsky 1991). However, after a disruption, resilience does not necessarily imply that society needs to return to the same state as before (Handmer & Dovers 1996). Resilience often embraces a set of attitudes regarding desired actions and the development of new opportunities. The fact that it represents an emergent system behaviour means that it is less difficult to identify resilience as it occurs than to create it where it does not exist, which is due to the above-mentioned complexity of the interrelated system. The ability to handle singular or unique events seems to be a common way of conceptualising resilience (Kendra & Wachtendorf 2003). Resilience can also be defined as the ability of a society or system to maintain functions in society (i.e., critical infrastructures) when it has been subjected to a chock (Rose 2007). Moreover, the concept can be seen as another way of conceptualising change (Miles & Petridou 2016).

In order to maintain and change its processes, a system must master entropy. According to the second law of thermodynamics, the entropy of a closed system strives towards a maximum. In short, this implies that entropy increases due to irreversible processes, such as an increase in friction or pressure or a loss of differentiation. In organisational systems, this increase in entropy may relate to increases in administrative tasks or meetings to co-ordinate collaboration. In addition, such processes tend to affect each other, which, in turn, often leads to a further increase in entropy. Thus, entropy is a measure of the amount of resources (energy) unavailable for carrying out purposeful work in a system. Purposeful work here refers to the critical core process that a system is intended to carry out, such as identifying and prioritising critical infrastructures or transmitting power from a production site to a consumer. In a similar sense, entropy is considered a measure of the lack of knowledge in a system (Shannon 1948).

Research has studied the relationships between processes within a system and an external force.[5] Such an external force is attributed to

5. See Maxwell (1871): The theory of heat and 'The sorting Demon of Maxwell' (1879). In *Nature* 20(501).

possessing ultimate knowledge of the system in order to affect entropy, keep a system in a steady state and facilitate the deliberate transformation of the system. However, the complexity of the societal system involves different layers of ambiguity and uncertainty, which would imply an external force that is at least equally complex as the steering system, not only in the context of risk governance and crisis management.

In complex technical systems, such as the power system, a major failure may lead to cascading effects that pose severe consequences for society (Hines et al. 2009; Vaiman et al. 2013), which also was the case with the 2003 power outage that affected southern Sweden and Denmark (see Excurse – Power outages). According to Perrow (1981), accidents are 'normal' or inevitable in some types of technological systems, including nuclear power production. Based on a study of the 1979 nuclear power plant accident on Three Mile Island, Perrow (1999) developed the Normal Accident Theory (NAT), which casts doubt on the excessive trust in technological systems. The theory assumes that a failure in one part of a tightly coupled system will spread to another part of the system and even result in increasingly larger failures, meaning that the accident was an inevitable outcome (Perrow 1999). This theory is based on the example of a nuclear accident but would also apply to other complex technological systems, such as the power system. However, power systems apply the N-1 criterion, which is meant to mitigate outage risks and ensure system availability in the event of component failure by means of additional available redundancy.[6]

NAT has been criticised for being too narrow as it only includes a few numbers of accidents occurring within a defined technological system. According to this critique, it is not possible to use the theory for the majority of accidents. Furthermore, the theory is considered too vague and ambiguous in terms of whether an accident constitutes a component failure accident or a system accident (Hopkins 1999; Shrivastava et al. 2009).

6. https://www.emissions-euets.com/internal-electricity-market-glossary/820-n-1-criterion

Definition: Risk Governance

Risk governance concerns the management of risk in society and thus includes both public and private actors as well as actors from the third sector. In general, it consists of four phases:

- pre-assessment
- appraisal
- characterisation/evaluation
- management

RISK GOVERNANCE AND CRISIS MANAGEMENT

There is no such thing as 100% security or reliability over time due to component and system behaviours such as adaption, emergence and entropy. Thus, the remaining questions concern which risks need consideration, how and to what extent risks should be mitigated and how emergencies and crises should be handled.

To address the systemic challenges outlined above, Manyena (2006) has argued that the concept of resilience can help us better understand risk management in general and the concepts of risk and vulnerability in particular. According to Rhinhard and Sundelius (2010), for example, the ability to work across borders constitutes an important basis for societal resilience. The authors have emphasised that co-operation improves resilience in a crisis since it increases (i) the level of co-ordination, including risk communication, decision-making and policy implementation; (ii) resource distribution; and (iii) building trust and social capital. Boin and McConnell (2007) have also pointed out the limits of crisis management in critical infrastructures and the need for resilience. They have stated that a crisis in itself does not necessarily lead to change but that established policies, procedures, cultures and legitimacies will be challenged during a crisis or disaster (Boin & McConnell 2007).

As indicated, resilience research has often recognised individual adaptive capacity as an element of societal resilience as it does not necessarily mean a return to a previous state but rather a new state of society, adjusted to new conditions.

Risk governance focuses on the political management of risk in society and thus includes both public and private actors and actors from the third sector – non-governmental and non-profit organisations and associations (Renn 2008). According to Renn (2008), it includes four phases: pre-assessment, appraisal, characterisation/evaluation and management. From a vertical perspective, risk governance is close to multi-level governance and proceeds from the local and regional levels to the national, supranational and global levels. From a horizontal perspective, it includes the public sector, industry, academic community, civil society and non-governmental organisations (Renn 2008).

Furthermore, risk governance is context-dependent and influenced by organisational capacity, political culture, actor networks, social climate and risk culture (Renn 2008). Risk governance is often considered a complex social activity carried out in multi-level and multi-directional networks (Boholm et al. 2012; Hood et al. 2001). In this respect, Sweden is often considered a special case with its tradition of building consensus (Boholm et al. 2012; Löfstedt 2005). Risk governance thus includes the implementation of strategies to enhance societal resilience. However, such efforts call for proper strategy development, including not only a consistent statement of strategic objectives but also operational goals and creating concrete measures ensuring the evaluability of the policy (Große 2018a). Studies have shown that co-operation, information sharing and discussion among relevant stakeholders represent key aspects that must be based on trust between the actors involved in planning and implementation (Große 2018b, 2019). For example, studies of stakeholder-based governance systems stress the importance of appropriate exchanges of data and information among the participating actors, such as policymakers, critical infrastructure operators, officials at public organisations and private businesses, to maintain the relevance and development of the strategy (Große & Olausson 2018, 2019). Such exchanges often require adequate information technologies and formal rules that facilitate collaboration and ensure security (Große 2021a, 2021b). Finally, governance must acknowledge the relevance of appropriate timeframes for actions as the various actors have different conditions to consider.

Co-operation in more or less formalised networks that represent the governing system of stakeholders from the public and private sectors is key in the concept of governance in general and in critical infrastructure protection in particular. Crisis management also depends on leadership for co-operation and co-ordination as well as individual experiences from other crises. A study of preparedness work among municipal leaders in Sweden has identified three categories of factors explaining the work motivation with issues related to risk, societal safety and being prepared for crisis (Enander et al. 2015). Based on the results of this study, a model was developed aimed at identifying opportunities and barriers to crisis preparedness at the municipal level. This model includes factors related to the organisational and environmental context, activities that have been undertaken and individual-related factors. All three categories are influenced by actual crisis experiences (Enander et al. 2015).

Palm and Ramsell (2007) have emphasised the importance of trust for co-operation and co-ordination regarding emergency management. However, a lack of resources for individual actors may increase the necessity of co-operation and co-ordination in policy networks. In order to be effective, mutual understanding and a willingness to listen to one another are crucial for the actors involved to develop trust within the policy network (Palm & Ramsell 2007). In their study of the views of civil defence directors on co-ordination and co-operation in crisis management, Wimelius and Engberg (2015) have shown that there is no clear way of resolving conflicts in crisis management in Sweden. Instead, the co-ordinators express hope that consensus will be achieved through better governance, improved network governance and more resources. On the other hand, they also find that Swedish crisis management is governed too weakly and that it lacks continuity. Trust is a crucial concept in this context (Wimelius & Engberg 2015).

Thus, collaboration and co-operation are key factors for obtaining a resilient policy for power shortages (Rhinard & Sundelius 2010). Considering the STYREL policy, the implemented planning process seeks to ensure a reliable electricity supply that maintains important functions during a power shortage. Since STYREL is part of the Swedish crisis management system, it requires proper co-operation and collaboration between the actors representing the public and private sectors. Furthermore, it involves actors representing different levels of the public administration ranging from municipalities and regions to national authorities in a multi-level planning process.

MULTI-LEVEL PLANNING

As indicated above, the risk and crisis management of society entails planning at multiple levels and involves actors from both the public and private sectors. Although considering the benefits of a plan during

Definition: Multi-Level Planning

Multi-level planning has three major characteristics:
1. differentiation of hierarchical levels
2. decomposition of an overall issue into single problems
3. co-ordinated solution of these single problems

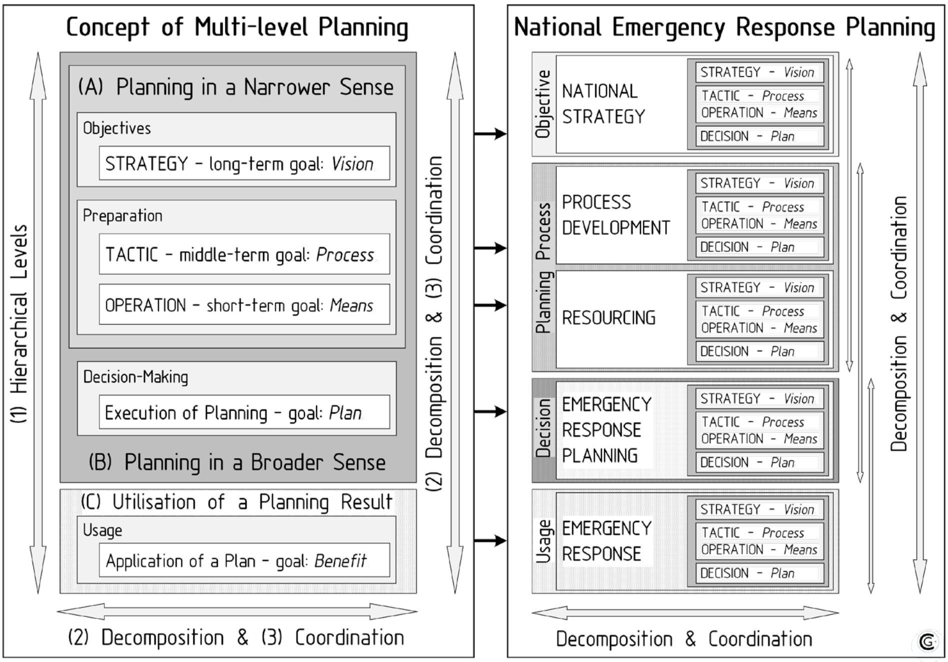
The multi-level planning concept represents a means of addressing complex problems and results, ideally through a plan that can be executed and monitored.

planning improves the outcome, such integration may be difficult in national emergency response planning due to its multi-agency character (Große 2019). Hence, such planning requires decomposing and co-ordinating goals and means throughout a multi-level approach (Allouche & Berger 2011). We suggest a separate consideration whilst maintaining a holistic perspective in order to meet the complexity, uncertainty and ambiguity associated with the systemic nature of this type of multi-level planning.

Figure 2 summarises the three major characteristics of multi-level planning:

1. *Hierarchical levels of planning* can be represented by strategic, tactical and operational perspectives – planning in a narrower sense (A) – while the time horizon decreases and the degree of detail increases (Schmidt & Wilhelm 2000). These planning perspectives generally consider the planning stages before a production process, and they here refer to goal definition (strategy), process development (tactic) and sourcing (operation) before decision-making. The execution of the decision-making process – planning in a broader sense (B) – results in a plan, such as an emergency response plan. Subsequent planning levels use higher-level plans as input. Implications related to a produced plan and its further usage – utilising the result of planning (C) – are particularly important in the public sector due to conceivable economic, societal and environmental consequences of a critical infrastructure failure due to an electricity blackout. These circumstances force the government to utilise the plan appropriately in order to maintain public values (Bryson et al. 2014).

Figure 2. Characteristics of multi-level planning applied to national planning for emergency response.



2. *Decomposing* complex planning tasks into single problems entails concretising goals and means during processes, while goals and means of lower-level processes must conform to interconnected higher-level ones (Munro et al. 2011), visualised by arrows in Figure 2. Otherwise, conflicting goals may affect decision-making and motivation (Stasser et al. 2015), which may further impact the benefits of a plan.
3. *Co-ordination* occurs in two directions, represented by arrows in Figure 2: horizontal, alongside a process, and vertical, across organisational structures accompanying hierarchical and network constructs. This co-ordination provides a basis for achieving efficiency and effectiveness during processes. Thus, in addition to

> concretely defining communication paths and relevant documentation, there needs to be a focus on leadership efforts, guidance and direction throughout established structures (Bryson et al. 2014). Such structures may relate to networks within organisations or inter-organisational systems-of-systems, such as public-private governance networks.

The fact that planning applies a future perspective and intensely processes mostly incomplete information necessitates communication and collaboration among the actors involved in order to cope with uncertainties arising from a lack of knowledge in complex and rapidly changing social systems (McGuire 2006; Poister 2010). This type of uncertainty is highly interconnected with planning and decision-making and arises at all levels of planning; for example, with respect to the overall objectives, the levels of concern, interdependencies between infrastructure assets as well as which consequences emerge and for whom following a critical event. For instance, a critical power shortage is likely to result in cascading effects posing severe consequences for society (Hines et al. 2009; Vaiman et al. 2013).

The Research Project – Methods and Limitations

The multi-disciplinary research project 'From authorities to citizens and back', mainly conducted between 2015 and 2018 at Mid Sweden University (Olausson et al. 2018), inspired us to write this book. This project picked three Swedish counties for studying co-operation and collaboration among stakeholders in the context of a public policy – the policy of STYREL. The study employed several methods for data collection and analysis. It examines documents that relate to the Swedish case, interviews and a survey with involved experts. Over the course of the project, interviews with a total of 66 individuals were conducted. This number of personal contacts and individual views not only facilitated maintaining a holistic perspective during the study but also follow-up questions to achieve a deep understanding of the case. Since the use of multiple sources of evidence arguably benefits the overall quality of case study research, we also incorporated case-related documentation and a survey. Confidential meeting minutes, field notes, individual experiences and reflections of the researchers involved enriched the material. Archival records could not be included due to aspects such as information security or unavailability (Große, Olausson & Wallman-Lundåsen 2021).

In general, the policy process is often described as the creation and development of (public) policy, including the roles of the actors involved and the particular context (Weible et al. 2012). A policy process can be seen as a circle including six significant steps: agenda setting, policy formulation, policy adoption, implementation, evaluation and termination (Hill & Varone 2017; Lasswell 1948). The theory of multiple streams (Kingdon 1984) specifically focuses on the agenda-setting stage of the policy process. In addition, the implementation stage of public policy has developed into somewhat of a distinct research field, where Mazmanian and Sabatier (1981) and Pressman and Wildavsky (1984) serve as two important examples. Other types of policy analysis concentrate on the role of policy networks (Rhodes 1996; Sørensen & Torfing 2016), the governing of common pool resources (Ostrom 1990) or the role of policy entrepreneurs (Petridou & Olausson 2017; Schneider et al. 1995).

To understand the policy, an analysis needs to include evidence from all six steps in the policy process, even though we here focus on the implementation and evaluation of the STYREL policy. First, this research studied publicly available textual material regarding STYREL. This collection mainly consisted of official policies and user instructions, legal regulations, public investigations and reports as well as evaluations of the pilot in 2009 and the first run of STYREL in 2011. Evaluations of the second run in 2014 were not publicly available. Second, three counties were selected for conducting semi-structured face-to-face interviews. One county represented the rural countryside, one county included heavy industry close to the capital, and one county included one of the three major Swedish cities. The variation in the counties in terms of size and structure allowed for a broad spectrum of local experiences, requirements and constraints, which imparted appropriate information power in the sample and supported a thick description of the STYREL process. The proceedings further entailed anonymising and aggregating the material and results to secure sensitive information with regard to both privacy and confidentiality. Third, to broaden the view of particular issues, the survey encompassed all 21 counties in the first step and, in the second step, analysed the 10 power grid operators that stabilise the power grid during the initial phase of a power shortage. The survey posed 34 questions about the respondents' perceptions of the effectiveness and efficiency of STYREL in general and the proceedings of the planning process within their respective areas of responsibility in particular.

Since planning for power shortages relies on sensible data and targets weaknesses in systems, access to data was restricted, which resulted in further obstacles with regard to the policy and interview study. Consequently, the data collection relied predominantly on publicly available Swedish documents and personal interviews.

However, the publicly available documentation regarding the creation and development of the Swedish planning is fragmented (Große et al. 2019). None of the co-ordinating actors or any central body collected any documentation or evaluation from the participants in the process. One obstacle to structured data collection from important documents is the variation in the content of the documentation between the actors. Moreover, some documents were publicly available, whereas other types of documents and information were undetectable (Große, Olausson & Wallman-Lundåsen 2021). For example, we did not find any records of the development process or any evaluations of the second round of planning. This suggests that such documents do not exist, are classified or that the owner does not want to share this information or has not considered sharing it.

The research project serving as the basis of this study proceeded over a period covering the interval between two iterations of the STYREL process. As the results indicate, staff changes and information loss occurred during such intervals and impacted the empirical material collected during this period. However, at the time of writing this book, the third iteration of STYREL has been postponed several times due to the reasons described below.

After this introduction, containing an overview of the theoretical and empirical underpinnings of this book, the following chapter provides a brief background regarding power supply and the Swedish crisis management system as well as a short international overview of similar approaches.

Background and the Swedish Context

THIS CHAPTER PRESENTS an in-depth background on electricity supply, including a few technical requirements and conditions as well as challenges accompanying current trends in society. In addition, it presents the Swedish crisis management system, including perspectives from the national, regional and local levels. It also provides a brief international overview of similar planning systems.

Electricity Supply

Since other infrastructures largely rely on the availability of electricity, the power supply has a key position among the interdependent sectors of critical infrastructures (Rinaldi et al. 2001). Hence, electricity is essential for modern society, whereas the demand for power supply at any time must confront physical challenges with regard to, for example, storage. Electricity has so far been difficult to store while offering good transfer properties, which is why engineers started building power grids 130 years ago to enable the transfer of electricity from power production sites to power demand sites. At the turn of the previous century, power grids served local and regional purposes within and across political borders in Europe. Increasing demand, technological developments and changing political ambitions were key drivers behind the formation of the current power grid structure. The power grid in Sweden is part of the Nordic power grid system, which involves parts of Denmark in addition to Norway, Finland, Åland and Sweden in a common electricity market. In 2019, a legal agreement was concluded between the Nordic power transmission system operators (previously constituting Nordel) to align with the European Network of Transmission System Operators for Electricity (ENTSO-E).[7] However, the establishment of Nordel in the 1960s exemplifies how organisational considerations and political will have affected infrastructure developments in northern Europe apart from technical necessities (van der Vleuten & Lagendijk 2010a, 2010b). For example, the majority of power production in Sweden occurs in the north, while most of the demand is concentrated in the south of the country. In order to bridge this long distance with a low electricity load loss, high-voltage overhead power lines constitute the main, national power grid, which supplies electricity to lower-voltage grids, in this book referred to as regional and local power grids.

Similar to other power networks, the Swedish power grid must manage the grid frequency in the network to prevent blackouts. Grid frequency maintenance involves continuously balancing production and consumption to ensure the stability of network conditions. However, disturbances may emerge in all sub-systems alongside the power supply, namely the production, distribution and consumption of electricity. Apart from natural or weather-induced events, such as storms or falling trees, disturbances may also be caused by the aging of components. Human error, which resulted in a two-hour blackout in central Europe in 2006 (UCTE 2006), or cyberattacks, such as reported from Ukraine in 2016 (ICS-CERT 2016) and Russia in 2019 (Sanger & Perlroth 2019), represent additional causes of disturbances. Electrical installations contain various protection systems to prevent humans and devices from experiencing damage. Such local protection systems respond quickly to the cause of failure; however, even local protection can have significant repercussions for the power grid balance depending on the amount of electricity being severed (Gheorghe et al. 2006). Hence, disruptions associated with consumption require an electricity feed reduction, whereas disruptions in production require a reduction of consumption. Disturbances in the power grid may thus call for various adaptations in production and consumption in order to adequately meet the emerging conditions and immediately restore the grid balance at the local, regional, national and international levels (ENTSOE 2010).

7. https://www.entsoe.eu/publications/system-operations-reports/#nordic

Excurse – Power outages

The cascading effects that result from a single local event and cause or force a power outage do not only affect a local population but may also result in severe consequences for neighbouring countries. For example, in the US in 2003, compromised software at a power grid operator was the initial event in a line of severe problems during the following four hours. The blackout ultimately affected not only parts of the US for up to four days, but also parts of Canada for more than a week, which caused a considerable economic loss. In relation to this blackout, four main inadequacies were noted with regard to (1) system understanding, (2) situational awareness, (3) tree trimming and (4) the diagnostic support of power grid operators (US-Canada Power System Outage Task Force 2004).

In Switzerland in 2003, a nearby treefall in combination with a power overload caused a blackout in Italy and parts of Switzerland since the power lines between France and Italy did not work as expected. As a result of several problems, such as communication difficulties between actors, poor preparation for such situations and inadequate protection measures, the electrical blackout occurred 26 minutes after the treefall. Its duration varied from 1.5 hours in Switzerland and northern Italy to 19 hours in Sicily (Bachler & Näf 2003; Berizzi 2004). This blackout provoked a political dispute between the countries affected that involved mutual recriminations regarding causes, responsibilities and adequate measures. Evaluations concluded that although the Italian power system was incapable of managing the consequences, the blackout in Italy in 2003 was caused by the failures in Switzerland (Johnson 2007; UCTE 2004).

As seen in the Switzerland-Italy blackout, tree growth represents a major threat to the power grid and its function. This is especially the case in countries with large forested areas, such as Finland and Sweden which have the largest portions of land covered by forests in Europe and North America. In 2020, forest areas in Sweden and Finland corresponded to 73.7 percent and 68.7 percent of the countries' respective land areas (http://data.worldbank.org/).

However, instead of a fallen tree, the tripping of a unit at a nuclear power station in combination with a major fault in a substation shortly afterwards caused the major blackout in Sweden in 2003. After 90 seconds, southern Sweden experienced a blackout, which also affected eastern Denmark. The power supply was restored stepwise some 10 hours later. Although both national power grid operators viewed the co-operation as reliable, the Danish report identified further technical, managerial and policy issues. Apart from technical issues, such as maintenance of the transmission system and restoration of the power supply, it also presented communication issues between actors and with regard to the wider public as well as policy issues related to the electricity market and international requirements. Thereby, some similarities between the former two cases can be seen with regard to technical and management issues. (Elkraft System 2003; Larsson & Ek 2004; Svenska kraftnät 2003)

A recent major blackout in Turkey in 2015 implies that such planning is still relevant. The majority of Turkey experienced an electrical blackout, caused by an overload, 12 seconds after the initial event due to several cascading effects. According to the official report, this outage had no impact on neighbouring countries. The report stated only minor effects on critical infrastructures as most of these possessed their own emergency power supply during the power outage. Around ten hours later, the system was restored. (ENTSOE 2015)

An example from Ukraine covers cyberattacks on the power supply, which have recently been attributed to Russian state actors. In December 2015, such a cyberattack caused power outages affecting some 225,000 electricity consumers (ICS-CERT 2016). This example illustrates the growing concern regarding the risk of power outages following cyberattacks. For example, a report from the US Government Accountability Office in 2019 concluded that cyberattacks on the control systems used in power production and transmission are likely to cause widespread power outages and criticised the lack of developed plans for electricity grid cyber security (GAO 2019).

In addition, extreme weather conditions may further increase the risks accompanying blackouts. A few recent examples include shutoffs in relation to wildfires, such as in California in 2019 and 2020, Australia in 2020, Sweden in 2018 and Greece in 2021; flooding, such as in Germany in 2021; or ice storms, such as in Texas in 2021. The absence of more severe blackouts in Europe in recent times implies that power grid operators have made progress in terms of co-operatively ensuring a permanent and reliable power supply. A recent example of a severe incident that was successfully managed is the separation of the Continental Europe Synchronous Area in January 2021. Following cascaded trips of several transmission network elements triggered by overcurrent protection measures, the power transmission system was separated into two synchronous areas within 20 seconds. While the south-east area yielded a surplus of production, the north-west area was confronted with a surplus of load and thus a quickly decaying frequency. Among other measures, the under-frequency situation was managed by contracted load shedding in France and Italy. An hour later, the power grid operators had resolved the incident and resynchronised the continental Europe power system. (ENTSOE 2021)

However, severe weather conditions constitute a growing threat due to climate change. For example, winter in northern Europe is normally a critical period for the power system due to the reduced thermal capacity of power lines and a higher demand for heating. The long transmission distances in northern Europe, one of the similarities to the Turkish power system, challenge a reliable power supply. In the winter of 2015–2016, during such a critical period, only reserves were left to manage this all-time high demand situation (ENTSOE 2016b) involving Sweden, Finland, Norway and eastern Denmark. Although the forecast for the winter of 2016–2017 indicated a similar or even worse situation (ENTSOE 2016a), the weather was quite warm during the critical period, which defused the situation (ENTSOE 2017).

Regardless of the cause, long-lasting power outages entail considerable cascading effects since the electricity supply is critical to a number of infrastructures, such as water, food and fuel supply, heating, cooling, lighting and information technology. As a consequence, the preparation and co-ordination of emergency responses and interrelated communication efforts should also consider a variety of outage scenarios that hamper communication between the actors responsible and the wider public.

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Measures to Balance a Reliable Power Supply

A few decades ago, power production mainly involved large plants, such as coal, nuclear or hydroelectric power plants. These types of generation units have a plannable capacity regardless of weather conditions. A stronger focus on renewable energies as part of electricity production has recently yielded wind parks and solar panels with a varied spectrum of capacities as well as an increased number of power producers. In particular, the output of these generation units depends on current weather conditions. Maintaining the balance of the power grid used to require automatic disconnection when the frequency exceeded 50.2 Hz. Studies have shown that, depending on the effect that is currently installed, this general requirement runs the risk of resulting in an over-adjustment (Bömer et al. 2011). Such an incorrect adjustment may prompt further instability in the grid and cascading consequences. Therefore, regulations now discourage an automatic disconnection of production units between 47.5 and 51.5 Hz (ENTSOE 2014). If the frequency drops below 47.5 Hz, production plants are disconnected to protect them from breaking down, which, in turn, requires a reduction in consumption to balance the frequency.

The reduction of electricity consumption, which is known as *load shedding*, constitutes a measure for stabilising the frequency of the power grid. It is applied when the frequency is low and no reserve can be activated or imported. ENTSO-E has recommended a load shedding stepwise up to 50 percent of consumption between 49.0 and 48.0 Hz and an automatic shedding of heating pumps between 49.8 and 49.2 Hz for continental Europe (ENTSOE 2010). The members of the continental power grid collaborate with the members of the Nordic grid in terms of balancing the grid through instabilities, which also stresses the significance of a European dimension in planning critical infrastructure protection.

In Sweden, the planning for load shedding is twofold. The first part concerns a plan for manually disconnecting power consumption (MFK). All power grid operators are legally obligated to independently perform this MFK planning, which must enable each grid provider to disconnect at least 50 percent of the actual load. Since the current load may vary considerably during a particular period based on aspects such as season, weather conditions or time of day, MFK planning is based

Load shedding

Manual load shedding mainly occurs in situations in which the electricity demand slowly increases until production and transmission are finally unable to fulfil the demand.

Automatic load shedding mainly occurs in situations in which a sudden imbalance emerges due to, for example, a failure in a power plant.

on the maximum load that occurred in the previous year. The resulting plan for disconnecting power consumption involves the results of STYREL to ensure that critical infrastructures receive electricity with as few disturbances as possible. The second part addresses a plan for automatic disconnection of demand (i.e., automatic load shedding, AFK[8]), which applies if the frequency drops significantly to prevent a blackout. This AFK planning, which only providers directly connected to the national grid in the southern part of Sweden must perform (i.e., south of the 61st parallel north according to Svenska kraftnät (2001, 2021b)), considers between 30 percent and 50 percent of the actual effect, while the manual and automatic disconnection scheme may overlap as little as possible. MFK and AFK planning also involves larger boilers and heating pumps, which is similar to continental Europe. In general, the power grid operators strive to plan for such measures with a minimum of consequences for society at large.

The Swedish Crisis Management System

In order to understand the context and risks, several relationships among the various elements of the Swedish risk and crisis management system require special attention, such as the relations between STYREL and the crisis management system in general and the risk and vulnerability analyses (RSAs[9]) in particular.

First, we need to define some characteristics of Swedish public administration. The Swedish administrative system is based on a

8. AFK is an acronym for 'automatisk förbrukningsfrånkoppling' (i.e., automatic load shedding).
9. RSA is an acronym for 'risk och sårbarhetsanalys' (i.e., risk and vulnerability analysis).

number of principles that might be summarised as organisationally independent authorities, a sectorisation of the administration and local self-government. Independent authorities imply that no authority, not even parliament or a municipality's decision-making body, may decide how an administrative authority in a particular case is to decide in a matter concerning the exercise of authority against an individual or a municipality or concerning the application of law (SFS 1974:152). The sectorisation of the administration means that national authorities are responsible for a defined sector. Finally, local self-government means that municipalities themselves manage the matters existing within the municipalities (SFS 1974:152). The government can only rule through laws and ordinances, state subsidies and agreements.

In this respect, Sweden to some extent differs from the other Scandinavian countries. First, ministerial rule is forbidden in Sweden. This means that a minister of the Swedish government cannot interfere in how a national agency or a municipality chooses to execute its responsibilities. This is possible in both Denmark and Norway. In these countries, network arrangements have been set up to foster better co-ordination between the actors in case of a crisis (see Christensen et al. 2016).

The Swedish crisis management system is based on three principles. First, the 'responsibility principle' states that an actor responsible for an activity in normal conditions is also responsible for this activity during an emergency. This principle also includes a responsibility to co-operate and collaborate with other actors affected by the crisis. Second, the 'similarity principle' states that operations should be organised in the same way during emergencies as in normal conditions. Third, the 'proximity principle' states that emergencies should be handled at the lowest possible level in society. The system assumes co-operation and collaboration between the actors involved in a specific crisis. The proximity principle implies that municipalities and regions are often involved. Thus, they must co-operate and collaborate with other actors, both public and private. In some cases, actors from the third sector are also involved (i.e., non-governmental organisations, associations, co-operatives and civil society), which may include different types of volunteers.

Furthermore, the municipalities representing the local level (2006:544) and the CABs at the regional level (2015:1052; 2017:868)

Three principles of Swedish crisis management

The responsibility principle implies that actors responsible for an activity or process in normal conditions retain this responsibility during a crisis.

The similarity principle suggests that societal functions should, to the greatest extent possible, be carried out in the same way during a crisis as during normal conditions.

The proximity principle states that the actors closest to the event should handle the crisis where it occurs; thus, a municipality or county/region should primarily handle a crisis.

are both responsible for co-ordinating necessary crisis management measures taken by actors during an extraordinary event. This responsibility further includes providing information to and communicating with the public. At the regional level, the CAB should also prioritise and concentrate available national and international resources during a crisis (MSB 2017). Finally, each national authority is responsible for a defined sector regardless of geographical responsibilities. This means that the authority should provide support in the form of expert knowledge and resources during a crisis. If a crisis involves several areas of responsibility, the support needs to be co-ordinated, thus implying co-operation between the authorities involved.

If the actor responsible does not possess the necessary resources, national level agencies can support it (Pramanik et al. 2015; MSB 2018; Tehler et al. 2012). According to the Emergency Services Ordinance (SFS 1986:1107), a CAB can take over responsibility for the rescue services in one or more municipalities if the situation calls for extensive rescue operations, which was the case during the wildfires in 2018 and the Covid-19 pandemic. This also implies that a CAB has to co-ordinate relevant actors in its county (MSB 2018). Similarly, if a national authority takes over responsibility, it will also be responsible for the co-ordination. Since there is no explicit process for resolving possible conflicts within the Swedish crisis management system, the co-ordinating role places immense demands on CABs. Research on the Swedish risk and crisis management system has indicated that clearer governance, improvements in network management and increased resources and continuity constitute measures for improving co-operation among various actors in the county (Große 2021b; Olausson & Nyhlén 2017; Wimelius & Engberg 2015).

The principle of responsibility in Swedish crisis management has sometimes been criticised as a crisis is not the same as normal conditions. Subsequently, those responsible for an activity in normal conditions must get support from other actors during a crisis (Danielsson & Öhman 2021; Enander 2020; Johansson et al. 2018). This requirement means that it is important to maintain and preserve functional networks to ensure collaboration and co-operation during crisis conditions. Recurring exercises are thus acknowledged as important means for maintaining and improving such co-operation capabilities (Danielsson 2016).

These three principles guide all governments in Sweden and, by definition, the organisations in charge of handling crisis situations (MSB 2015). These principles are not defined in law but should instead be understood as serving as a background to the current regulations regarding crisis preparedness and the mission and mandate of the various actors. As for legislation, three major laws regulate the Swedish crisis management system: (1) *Ordinance (2006:637) on municipalities' and regions' measures before and in the event of extraordinary events in peacetime and heightened preparedness*, which regulates the responsibility of the above-mentioned actors in the event of a crisis; (2) *Act (1992:1403) on total defence and heightened preparedness*; and (3) *Ordinance (2015:1053) on total defence and heightened preparedness*, which aims to reduce vulnerability in society and develop a capacity to manage a state of alert. In addition, *Ordinance (2015:1052) on crisis preparedness and measures by authorities responsible for surveillance in the event of heightened preparedness* addresses government agencies and aims to reduce the vulnerability of society in peacetime and a state of alert.

Since the resilience of society is an important part of the NATO treaty, civil preparedness to ensure a resilient society represents a key pillar of the alliance. In Article 3, the NATO treaty states: 'In order more effectively to achieve the objectives of this Treaty, the Parties, separately and jointly, by means of continuous and effective self-help and mutual aid, will maintain and develop their individual and collective capacity to resist armed attack.'[10]

10. https://www.nato.int/cps/en/natohq/topics_132722.htm.

Although a resilient society and civil preparedness by nature represent a national prerogative, the NATO alliance is important for both supporting member states as well as co-ordinating national efforts to make the alliance and its members more coherent. For this purpose, seven baseline requirements have been defined, one of which concerns resilient energy supplies and power grids (Garriaud-Maylam 2021). Therefore, STYREL represents an important approach in terms of creating conditions for a resilient society in the event of a power shortage.

Risk and Vulnerability Analysis

Risk and vulnerability analysis (RSA) is an important tool in the Swedish system of risk governance and emergency preparedness. Every other year, these analyses aim to identify risks and vulnerabilities within the areas of responsibility of government agencies, regions and municipalities. According to the legislation (2015:1052), the actors should seek to reduce the level of vulnerability within their area of responsibility by conducting an RSA. This analysis includes identifying and assessing the probabilities and consequences of extraordinary events and the measures for minimising interrelated vulnerabilities. It also involves the responsibility to co-ordinate planning and preparing efforts of actors concerned within each actor's area of responsibility.

Studies of RSAs at the municipal level stress their importance, but they also show that several areas need further consideration and improvements. Further developments must address the needs to improve the systematic and comprehensive work with RSAs to shift the focus from the municipality as an organisation to the municipality as a geographic area and to include different municipal scenarios. How to approach these challenges, however, depends on the supposed role of RSAs in the crisis management system (Hassel 2012).

As discussed further below, the representatives from the municipalities and the CABs expressed during the interviews that their work with STYREL should be more closely related to RSAs than what is the case in the current approach. Today, the two processes run in parallel in many municipalities, whereas different administrators handle the two processes. This means that there is little or no connection between the two processes at the local level (Große 2017a).

International Outlook

Large segments of the energy supply network are connected to several countries. For example, the Nordic interconnected power network is synchronised, and a failure in Sweden can quickly impact neighbouring countries and vice versa. Such cascading effects can similarly emerge in the European continental power grid as well as in other power networks in other regions. In an international comparison of preparedness planning against power disturbances, there is no system completely matching the Swedish STYREL, but there are a few approaches exhibiting some similarities. Germany, for example, has proposed a planning approach, called CIP Strategy, which exhibits similarities with the Swedish case. The National Infrastructure Protection Plan (NIPP) found in the United States (US) includes more sectors than the Swedish one. Canada applies a planning system similar to the US approach. The other Nordic countries have prepared measures to deal with a situation of power shortage within the crisis management systems.[11] However, at the time of writing, the planning systems in these countries exhibit few similarities to the Swedish one. In this section, we thus focus on the NIPP and CIP Strategy systems and how they relate to STYREL.

First, the comparison looks at how critical infrastructures are defined in the three planning processes. When STYREL was created, Swedish Civil Contingencies Agency defined critical infrastructure as 'a societal function of such significance that a loss of or a serious disturbance in the function would entail a great risk or danger to the population's life and health, the functionality of society or the fundamental values of society'. The definition also includes the 'physical structure whose functionality contributes to ensuring the maintenance of important functions in society' (MSB 2011). In addition, the referenced document defines the functions that are significant for society and which are associated with 11 sectors (see Table 1). At the beginning of the pandemic in 2020, Swedish Civil Contingencies Agency also recognised military defence as critical infrastructure (MSB 2020a, 2020b, 2020c:149). To align with other definitions in the European context, Swedish Civil Contingencies Agency has very recently redefined critical infrastructure as 'activities, services or infrastructures that maintain or ensure

11. https://ing.dk/artikel/norway-prepares-a-plan-power-rationing-259725

societal functions that are necessary for society's basic needs, values or security' (MSB 2020c). The new wording may be interpreted as a shift away from disturbances and consequences of a loss of functions towards ensuring a desired or sufficient level of society's functionality, which includes safeguarding society's core values and adaptive capacity (i.e., to tolerate disturbances to a certain extent). To assist public and private organisations in identifying critical infrastructures, a new list exemplifies important sectors in society. This list includes childcare and education, drinking water supply, sewage and waste, economic security, energy supply, financial services, trade and industry, health care and nursing, information and communication, food supply, public administration, order and security, employment, rescue service and civil protection and, finally, transportation (MSB 2021).

The German Federal Ministry of the Interior has defined critical infrastructures as: 'Critical infrastructures (CI) are organizational and physical structures and facilities of such vital importance to a nation's society and economy that their failure or degradation would result in sustained supply shortages, significant disruption of public safety and security, or other dramatic consequences' (BMI 2009). The policy subsequently specifies nine sectors to consider nationally (see Table 1).

The US has defined critical infrastructures as 'systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters' (US HS 2013; US PA 2001). The policy lists 16 critical infrastructure sectors. The NIPP was first called for in the Homeland Security Presidential Directive 7: Critical Infrastructure Identification, Prioritization and Protection in 2003. This directive required a national policy for federal departments and agencies to identify and prioritise critical infrastructures and key resources in the US and to protect them from terrorist attacks (US HS 2003). The planning processes include actors representing both public and private actors and require a kind of co-operation and collaboration between the actors in governance networks.

Whereas the German and Swedish planning processes are based on the perspective that the protection of critical infrastructure is necessary for maintaining the functionality of society, the US planning process targets the protection of critical infrastructure from external impact in the form of sabotage, vandalism and terrorist attacks. This different perspective is clear when assessing the designs of the three planning processes. Furthermore, the German and the US planning models include a more nuanced list of critical infrastructures, whereas the Swedish process solely focuses on electricity-dependent infrastructures. Instead, the Swedish model for identifying important functions in society and prioritising critical infrastructures presupposes the above-mentioned RSAs, performed by national agencies, regions and municipalities. Apart from RSAs, special planning processes have to some extent been considered and developed, not only for shortages of power (i.e., STYREL) but also for gas (StyrGas) and water supply (StyrVatten) (Swedish Food Agency 2017).

Table 1 presents the identified critical infrastructures. In Germany and the US, the infrastructures, societal functions and interrelated processes are included in the planning systems, namely CIP Strategy (Germany) and NIPP (US), respectively. Sweden lacks a common planning process for the protection of critical infrastructures. Instead, the sectors are defined in the legislation (2020:149) and in instructions from Swedish Civil Contingencies Agency. Although the recognition of critical infrastructures is similar, the difference is mainly found in the way society addresses mitigation measures to protect critical infrastructures and ensure their maintained functionality.

Table 1. Sectors of critical infrastructure (in the order listed in the policies).

Germany Defined in CIP Strategy	Sweden Defined in 2011	Sweden Defined in 2020	US Defined in NIPP
Technical basic infrastructure	Energy supply	Energy supply	Chemical
Power supply	Financial services	Financial services	Commercial facilities
Information and communications technology	Trade and industry	Trade and industry	Communications
Transportation	Healthcare and nursing	Healthcare and nursing	Critical manufacturing
(Drinking) water supply and sewage disposal	Information and communication	Information and communication	Dams
Socio-economic services infrastructure	Municipal services	Municipal services	Emergency services
Public health, food	Food	Food	Information technology
Emergency and rescue services, disaster control and management	Public administration	Military defence	Nuclear reactors, materials and waste
Parliament, government, public administration, law enforcement agencies	Protection and security	Public administration	Food and agriculture
Finance, insurance	Social insurance	Protection and security	Defence industrial base
Media and cultural objects (cultural heritage items)	Transportation	Social insurance	Energy
		Transportation	Healthcare and public health
			Financial services
			Water and wastewater systems
			Government facilities
			Transportation systems

The STYREL Approach

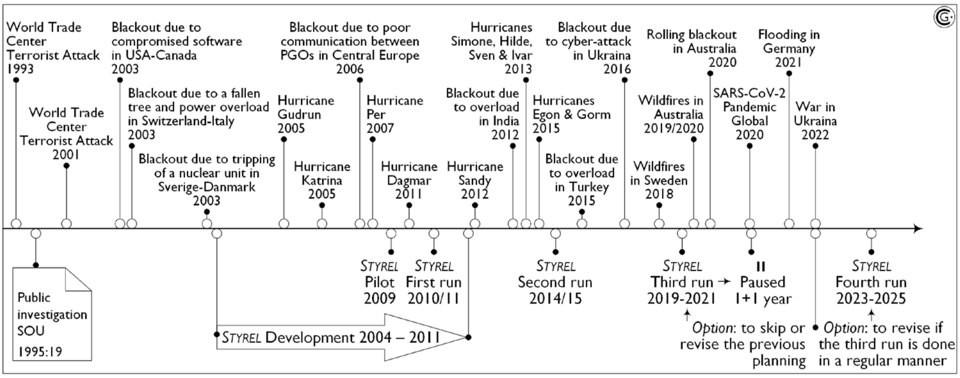
THIS CHAPTER ANALYSES what STYREL is and its role in society. It pursues the first question and analyses how STYREL evolved, which problem it was intended to solve, who is involved in the process, how the planning is intended to run and how it might affect important societal functions.

The Evolution of STYREL

In 1995, governmental studies had already identified the power supply as a critical area for national security and development in Sweden and noted a change in threats as well as an increased vulnerability regarding critical infrastructures (SOU 1995:19). However, compiling a ranking of power consumers to be prioritised in such events was not encouraged until after the major electrical blackout in Sweden and Denmark in 2003. In 1996, the electricity market embarked on a restructuring towards a private market, which resulted in a retrenched and fragmented power production and power supply landscape. Such fragmentation hampers decision paths and complicates the communication between public and private actors responsible for risk and crisis management at the societal level.

The 2003 blackout, which became a catalyst for the development of STYREL, was due to the tripping of a unit at a nuclear power plant that was shortly followed by a major fault in a sub-station. After 90 seconds, these events caused a blackout in southern Sweden with further consequences for eastern Denmark. The power grid operators restored the current stepwise and completed the restoration for the majority of

Figure 3. The development of STYREL along selected disaster events.



consumers after 10 hours. Even though both national grid operators considered the co-operation to be reliable, the Danish report identified technical, managerial and policy-related issues, such as a need to revise the principles for restoration 'with a view to ensuring the right order of priority for disconnection and reconnection of consumers' (Elkraft System 2003; Svenska kraftnät 2003). Since 2004, the Swedish Energy Agency (SEA) has been responsible for the development of STYREL. The approach stipulates a planning process involving a large number of actors in the creation of a policy, which is intended to support planning for and decision-making during a national power shortage situation.

As depicted in Figure 3, this approach was developed between 2004 and 2011 and was executed as a pilot in 2009 and full-scale on two occasions: in 2010–2011 and 2014–2015 (SEA 2014). A third national iteration was scheduled to run between 2019 and 2021. However, due to the Covid-19 pandemic, the process has at the time of writing been postponed twice by one year.

STYREL has been developed to facilitate the maintenance of vital functions in society during an under-frequency situation in Sweden.

The purpose of the procedure is thus to take inventory of national infrastructures dependent on electricity. It focuses on identifying consumers whose activities are essential for society with regard to health, safety and interdependent businesses prioritised consumers was a result of the amount of public and private actors involved and with the aim to address their various concerns in this context. During the early stages of the development of STYREL, it was considered relevant to identify both consumers providing critical infrastructures and the ones significantly harmed by a sudden electricity cut-off while at the same time needing to cover a high electricity demand (SEA 2006). The latter type of energy consumers mainly include. Since an emergency, whether it is caused or accompanied by a power shortage, requires prompt decision-making, there is an intention to prepare a rating of consumers in advance. The development of this approach for ascertaining these d processing industries, which depend heavily on an undisturbed power supply in order to protect them from significant economic damage. These consumers were considered able to significantly reduce their consumption for a period of time when being ordered to do so by their respective power grid operator (SEA et al. 2011). In turn, such a decrease in demand would reduce the necessity of effectuating an MFK. However, this perspective has changed during further development efforts. The main obstacle to this perspective was how an adequate time delay in disconnection from the grid should be included in an MFK being effectuated. Finally, this perspective was completely discarded after completing the first iteration of the STYREL planning process (cf. SFS 2013:282).

As demonstrated in more detail below, the planning approach not only identifies critical power consumers but also assesses their importance for society. For this purpose, it uses a scale to classify these key consumers in terms of importance. These priority levels have undergone a remarkable transformation during the development process. Generally, STYREL prioritises power consumers in decreasing order. At the 2007 development stage (SEA 2006), four priority classes were suggested (see Table 2, left-hand column). The first class comprised the most important consumers, which are essential for the functioning of society (i.e., critical infrastructures). Consumers able to quickly effectuate a large consumption decrease occupied the second class. The third class included consumers that are important to the economy and

Table 2. Classification scheme for prioritising critical infrastructure.

	Planning 2007		SEA 2010		MSB 2010 (in use)
1	Significant for societal functions	1a	Absolutely vital for societal functions 24/7	1	Great impact on life and health in a short time frame (a few hours)
		1b	Large reduction in power demand	2	Great impact on vital societal functions in a short time frame (a few hours)
2	Large reduction of power demand	2	Great impact on life and health in a short time frame (few hours)	3	Great impact on life and health in a longer time frame (a few days)
3	Important for economy and environment	3	Very important for the functioning of society and crisis management	4	Great impact on vital societal functions in a longer time frame (a few days)
4	All other power consumers	4	Very important for the environment	5	Represent large economic values
		5	Represent great economic values	6	Very important for environment
		6	Very important for social and cultural values	7	Very important for social and cultural values
		7	All other power consumers	8	All other power consumers

environment. Households and small enterprises formed the last class. The finalised planning should mainly suggest a priority list containing critical infrastructures and the remaining consumers prioritised according to the classification scheme. In addition, a list of consumers able to distinctly reduce their demand was required. Such a list should provide information on how quickly a set amount of current reduction could be effectuated, even on a percentage basis. Lastly, the classification of power consumers should lead to a ranking of operable power lines. Local grid operators should prioritise these lines based on the municipalities' classification lists and technical feasibility. It was suggested that municipalities might adapt the number of priority classes if considered necessary (SEA 2006) to facilitate local adaptions of the planning approach. Since tests of this proceeding indicated that it yielded too many power consumers at priority level 1, the Swedish Energy Agency suggested a more detailed list of priority classes (see Table 2, middle column (SEA 2010a)). After the pilots in 2008 and 2009, some additional changes were made. Decision-making at the county level now covers the regional power grid, and the power grid is no longer limited by county borders. Moreover, objects of national importance should be included in the decision process at the regional level. Table 2 below shows the evolution of the priority classes from the 2007 planning stage to the current classification scheme (MSB 2010). The final scheme excludes the group of consumers able to reduce their consumption. As before, it includes consumers with an impact on the economy and environment, but now in reverse order. Apart from this scale, no further decision aid is available to all actors.

The development of STYREL included tests of the approach at the local and regional levels. A few municipalities participated in four pilots in 2008, namely (1) Karlskrona, (2) Malå, Norsjö and Skellefteå, (3) Ludvika, Ljusnarsberg and Smedjebacken, and (4) Malmö (SEA 2008). In 2009, three CABs participated in pilots at the regional level, namely the counties of Blekinge, Dalarna and Skåne (SEA 2010b).

In these pilots, the aim was to test the planning process, identify ambiguities and problems, develop the simplest possible approach and calculate costs. In addition, it sought to enhance the level of knowledge regarding the roles of CABs and other actors in the prioritisation process and related problems that may arise simultaneously. In addition, a reference group followed and reviewed the development to identify opportunities for support, clarify roles and responsibilities for key actors and initiate further improvements. This group included representatives of the Swedish Association of Local Authorities and Regions, Svenska kraftnät, the Swedish Civil Contingencies Agency, the Energy Market Inspectorate (EI), the sectoral organisation Swedenergy, the Confederation of Swedish Enterprise, the CAB of Västernorrland and the municipality of Ludvika (SEA 2010b).

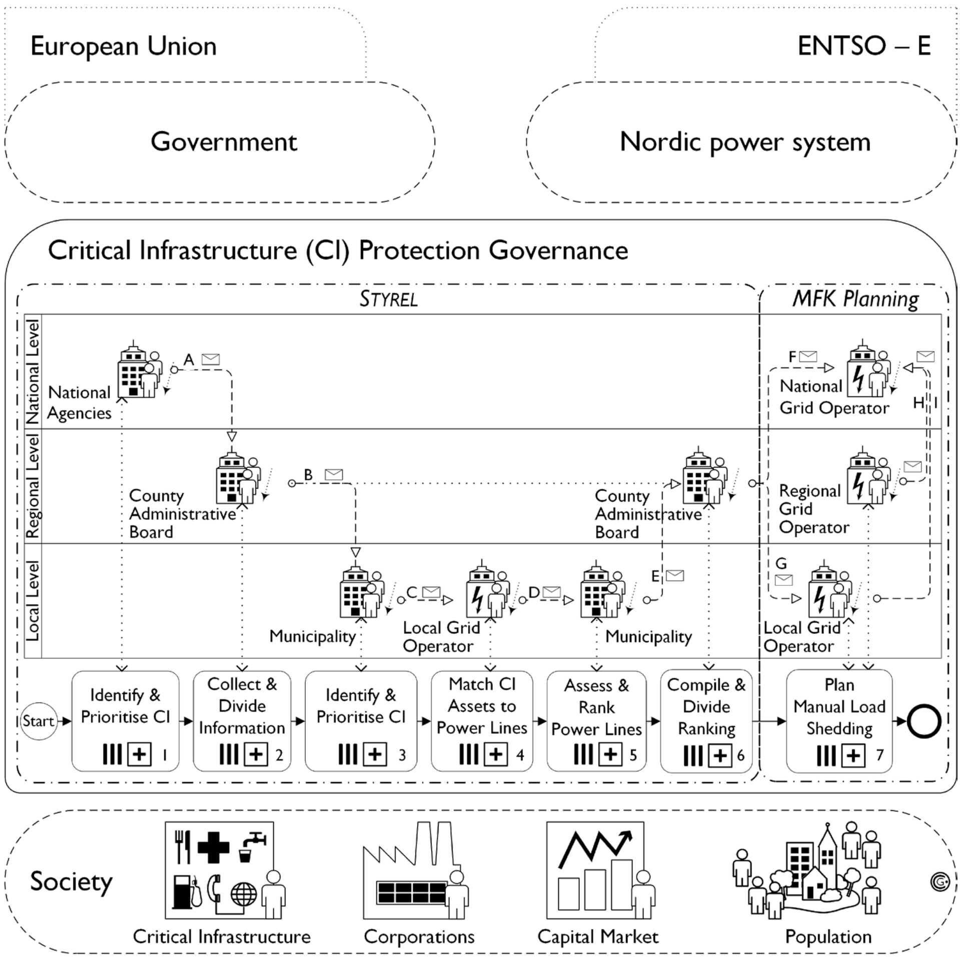
The Planning Process of STYREL

The process regularly applies a four-year interval and plans for an emergency response to power shortage situations in Sweden. As mentioned above, STYREL involves many actors at the local, regional and national levels. Table 3 lists these actors and their areas of responsibility, while Figure 4 illustrates these actors and their activities at different levels in the process. The policy-making process relies on collaboration among actors from public and private organisations as well as on highly limited technical support for decision-making, information processing and communication. Many actors represent the executing body, including various national agencies, CABs as regional co-ordinators, municipalities as holders of local knowledge and individuals as decision-makers, on a ranked list of prioritised power consumers. Furthermore, all power grid operators participate in the planning process. The communicated rationale for the approach is to reduce the negative consequences of power shortages for society. Hence, the Swedish case also serves as an interesting example of potentially competing interests in such a governance system for critical infrastructure protection.

To support the planning process, Swedish Energy Agency publishes a handbook and table templates. The multi-level process illustrated in Figure 4 was intended to apply as follows during the recent planning in 2014 (SEA 2014):

1. National agencies, which also include CABs to a certain extent, identify and prioritise the critical infrastructure (CI) operated by each of them by applying an eight-digit scale to classify CI (see Table 2).
   A. Each agency sends a list of ranked objects to each CAB (up to 21 in total) to which regional area of responsibility the CI object at hand belongs.
2. Each CAB merges the received lists of prioritised CI and divides them into portions corresponding to each respective municipality's area of responsibility.
   B. Each CAB forwards these lists to each municipality in the region to whom the list belongs.
3. Each municipality generates an inventory of local CI and prioritises the objects in accordance with the list in Table 2, which also involves the objects it receives from the CAB.

Figure 4. The STYREL process in the societal context.



C. Each municipality sends a request for further information regarding the prioritised CI to each power grid operator operating locally.

4. Each power grid operator matches the CI objects to power grid areas and power lines within the geographical area in which each provider operates the local grid.
   D. Each power grid operator provides information regarding technical feasibility in terms of control to each municipality having sent a request.
5. Each municipality consequently merges the CI objects into controllable power lines. The spreadsheet in use performs an additive aggregation of the objects' ranking scores, which yields a ranking list of the power lines. Each municipality is encouraged to assess this list of power lines to ensure that the order of power lines reflects the municipality's desired position.
   E. Each municipality sends the latter list back to the CAB in its region.
6. Each CAB then combines these lists from the municipalities in its jurisdiction, resolves conflicts between lines that cross municipal or regional borders and finally determines the ranking of power lines.
   F, G. Each CAB sends the final document, which contains the ranking of the local power lines in the region, to Svenska kraftnät and dedicates portions of the final document to each provider operating the local power grid in the region.
7. Each power grid operator plans for an MFK within its area of responsibility based on the results of STYREL in order to protect power lines supplying CI from early disconnection during an MFK.
   H, I. Each power grid operator sends the final MFK plan to Svenska kraftnät.

A few changes preceded the approach detailed above. The first outline of the first national run of the process included ten steps (SEA 2010a), as two more steps followed step 6 in the above list. The first emphasised the official decision made by the CABs on the ranking list in their respective county, while the other contained communication with the concerned stakeholders. Both these steps, however, have lost their distinct position. Ever since the second version of the handbook (SEA 2011), they are included in step 6 to a limited extent. On the one hand, these changes reduced the focus on public decision-making regarding the ranking of power consumers of vital importance for society. On the other hand, the communication between the actors in the planning as well as with concerned stakeholders in society has been downplayed to a certain extent. In addition, the first outline concluded with a tenth step focusing on the initiation of upcoming iterations with a four-year interval and possible updates of the final ranking list between iterations. A few reasons for the removal of this step may be highlighted. For example, the regulation finally entrusted the Swedish Energy Agency with the overall responsibility for the planning, which includes the initiation of the process iterations, thus superseding the responsibilities designated to national agencies or the Swedish Civil Contingencies Agency during the development efforts. Moreover, updating the ranking lists between the scheduled runs involves a considerable workload for the CABs, which is why the possibility of updating is still mentioned in the handbook and the website of the Swedish Energy Agency and is especially proposed as an option for either the third or fourth run, albeit in a downplayed form. However, the current approach includes a deliberate withholding of information between the successive actors in the decision-making process, which, in turn, renders such an update nearly impossible (Große, Larsson, & Björkqvist 2021). One example is that the CABs – in the first round of planning – had access to detailed information in order to participate more actively in assessing and balancing the priorities of the critical infrastructure assets at the county level. In the second iteration, the CABs received significantly more limited information to compile the results from the municipalities, which, in turn, will considerably complicate any update between the regular iterations of STYREL. This significant change in the sharing of information may be viewed as a strategy to avoid discussions about norms, assumptions and preselection preceding and limiting quantitative measurements. As Stone puts it: 'counting is political' since it includes a classification, such as the eight-digit scale in Table 2, results can be subject to 'political struggles to control their interpretation', as the majority of participants in the study repeatedly discussed, and, most problematically in the context of STYREL and CIP, '[n]umbers can create the illusion that a very complex and ambiguous phenomenon is simple, countable, and precisely defined' (Stone 2012).

The first run of the planning in 2011 concluded the development of the STYREL approach. The CABs were responsible for scheduling the planning in their counties. However, the CABs had to wait for the documents from the national agencies that are the preceding actors in the process. This not only caused a considerable delay in the planning at the regional and local levels but also uncovered additional issues, such as that other vital tasks carried out by the actors suddenly had to compete with the activities related to STYREL. Therefore, the second iteration of the planning in 2014–2015 included extended and specified deadlines for each actor while still considering seasonal tasks or holiday periods. However, the time frames were still considered too limited for each actor, which is why the third run was scheduled to run between 2019 and 2021. This means that the planning process has been rescheduled in several ways. First, the third iteration collided with elections and other tasks at the municipalities, such as risk and vulnerability analyses, resulting in this iteration being postponed for one year. Second, the timeframe of the process was extended as each actor was given time slots approximately three times longer to fulfil their tasks in the process. Finally, the third iteration started in 2019 as planned but was put on hold due to the Covid-19 pandemic. The process has been postponed twice by one year since then. It was intended to restart with step 3 at the beginning of 2022 and start STYREL 4 in 2023 to make up for the lost time. However, with the tense security situation due to the invasion of Ukraine, the proceedings were changed to allow municipalities to choose to what extent STYREL 3 and 4 will be conducted.[12] The new version of the handbook (SEA 2018) particularly emphasises the importance of information security and the focus of STYREL on electricity-dependent infrastructure and services.

Short Recap – The Role of STYREL in Society

The STYREL planning is part of the Swedish crisis management system and aims to proactively enhance preparedness (MSB 2011). The policy relates to the principles stated in the Swedish crisis management system. The priorities upon which the planning is based should be based on the priorities set out in the risk and vulnerability analyses.

Considering the STYREL policy, the implemented planning process seeks to ensure a reliable electricity supply that maintains functions

12. https://trk.idrelay.com/2930/arc?q=b72-8378&c=bf296db3f9

important for society even in the event of a power shortage. The communicated rationale for the approach is to alleviate consequences for society emerging when manual load shedding must be executed. The policy thus strives to increase society's adaptive capacity and enable society to function even during a crisis. The intention is also to increase society's resilience by maintaining important functions (Olausson 2019). This means that when such a power shortage in Sweden has been remedied, society can return to the situation existing before the electricity shortage.

Additional aims include creating a resilient power supply so that society is able to adapt to new conditions before, during and after a power shortage. Moreover, STYREL provides the actors involved with the opportunity to take inventory of critical infrastructures and services as well as the power lines that are the most relevant in case of a power shortage. The process goal is a plan that power grid providers can use as a basis for their response planning.

Since STYREL is part of the Swedish crisis management system, it requires co-operation and collaboration among the actors representing the public and private sectors for emergency response planning and the management of crises. The need for co-operation and dedicated networks is also one of the conclusions made from the pilots, for example in Blekinge. The CAB in this county stated that its ability to undertake an effective and relevant STYREL process primarily depends on the ability of the people responsible to collaborate (CAB Blekinge 2009). Dialogue, trust, transparency and networking were keywords for the creation of an effective process (Große & Olausson 2019). As part of the Swedish crisis management and civil defence system, STYREL can also play an important role in a future NATO membership, since the NATO treaty presupposes a resilient society in its member states. The planning system includes co-operation between several actors at different administrative levels in a multi-level governance system. The next chapter identifies and characterises the actors involved to varying degrees and their interactions in the STYREL planning process.

The Multi-Level Governance System

THIS CHAPTER PURSUES the second question and identifies relevant actors in STYREL and their specific conditions and relationships within this multi-level system of critical infrastructure protection. It further characterises their roles in the development, implementation and utilisation of the STYREL process in risk governance and crisis management.

The Stakeholders and Their Roles in STYREL

There is a great number of individuals, businesses, industries and public organisations, both nationally and internationally, that can be seen as stakeholders in STYREL. Table 3 details the key actors that are closely involved in the planning and describes their areas of responsibility in society and STYREL.

This large-scale system-of-systems, which carries out the planning for critical infrastructure protection with regard to the power supply, is embedded within a shared environment of societal responsibility. Each of the actors of this system is simultaneously a part of another system-of-systems as well. Therefore, the STYREL planning process is only a relatively small part of the total workload for each actor in its daily operations, and the particular environment of each actor dominates the interpretation of its role in the planning (Große 2021c).

Against the backdrop of national regulations, Swedish Energy Agency has the overall responsibility for the governance of STYREL, including its process, methods and development. However, the approach delegates responsibilities among the actors of the decision-making

Table 3. Actors in the STYREL Planning.

No	Actor	Area of Responsibility
I	Swedish Civil Contingencies Agency	National prevention, contingency and crisis management STYREL – process development
II	Swedish Energy Market Inspectorate	Control of the Swedish energy market, pricing and policies STYREL – process development
III	Swedish Energy Agency	Reliable and sustainable energy supply STYREL – process development, initiation of process execution (national), direction and guidance
IV	National power grid operator – Svenska kraftnät	Maintenance of the national power grid and power supply STYREL – process development, supervision of planning for and execution of MFK, which subsequently implements the results of STYREL
V	National agencies (n = ca. 100)	Various tasks affecting societal security STYREL identification and prioritisation of critical infrastructure that the particular agency operates, distribution of planning documents to the CABs where objects are physically located
VI	County administrative boards (n = 21)	Representing the government at the regional level STYREL – process execution (regional), distribution and compilation of planning documents, direction and guidance
VII	Municipalities (n = 290)	Representing society and acting locally STYREL – process execution (local), identification of critical infrastructure, collaboration with power grid operators (operating locally) and public and private operators of critical infrastructure (located locally), prioritisation of assets and controllable power lines
VIII	Power Grid Operators (n = ca. 160)	Grid maintenance and power supply at the regional/ local level STYREL – assisting municipalities with information on how critical infrastructure relates to power lines; planning for manual load shedding

system, which is apparent from the national regulations and Table 3.

At the national level in Sweden, numerous actors share responsibility for the electricity supply. Such a divided responsibility involves four national authorities. First, the Swedish Energy Agency is responsible for creating good conditions for efficient, resilient and sustainable energy use as well as a cost-effective distribution of energy. Second, the Swedish Energy Markets Inspectorate is responsible for supervision, regulation and licensing in the energy market. Third, the Swedish Civil Contingencies Agency is responsible for the crisis management system and the measures taken before, during and after an emergency or crisis. Finally, Svenska kraftnät is responsible for the Swedish power grid and operates the national grid. When a power shortage occurs, Svenska kraftnät is accountable for and permitted to impose an MFK, which is meant to save the power grid from collapse. When it comes to the execution of the STYREL planning process, some 100 national agencies have been involved. Many national agencies are requested to document the critical infrastructures for which they are responsible. However, national agencies decide individually when it comes to their participation, which has complicated the proceedings at the regional and local levels (Große 2021b).

At the regional level, CABs serve as points of intersection between governmental agencies and municipalities. Each CAB is responsible for co-ordinating work related to risk and crisis management in its own county. Therefore, the CABs occupy a central role as co-ordinators alongside the main part of the planning process but with limited influence on the quality of the process outcome. According to the reference process, the role of CABs goes both from the top down and from the bottom up. However, the latter is incomplete as the national level lacks co-ordination. The results of the research project show that more than half of the individuals responsible at the CABs had never participated in STYREL before, while one quarter had participated once and one-sixth of them had participated twice. This evident lack of knowledge is likely to impact their ability to co-ordinate the proceedings and process information (Große & Olausson 2018, 2019).

At the local level, all municipalities are legally obliged to participate in the planning. According to the third principle of the Swedish risk and crisis management system, primarily municipalities should handle a crisis when it occurs. Thus, they are responsible for performing not only RSAs but also participating in STYREL to take inventory of their infrastructure to identify power consumers that are vital for the local society. Similar to the CABs, almost half the officials at the municipalities and the power grid operators who participated in the research project had no experience with STYREL. In addition, the recent STYREL approach hardly involved large segments of civil society nor any non-governmental or private organisations. The results from the research project indicated that such proceedings stipulate a workload that surpassed the capabilities of the municipalities. This absence implies that the majority of privately-operated critical infrastructures are not represented in the plan applied by the power grid operators in their planning for load shedding.

In addition to assisting municipalities with matching prioritised power consumers to power lines during the planning, all power grid operators are also obligated to plan for an MFK (see Chapter 2) while considering the STYREL results as much as possible. When a power shortage occurs, the national grid operator is primarily responsible for MFKs in Sweden. Moreover, only nine out of the about 160 power grid operators in Sweden are currently delegated certain responsibilities during the initial phase of managing power supply disturbances. Five of these operators exclusively operate their own local grids and one transmits power to another local grid. The remaining are the three largest power grid operators in Sweden, operating both regional and local grids and transmitting power to 40, 50 and 60 sub-operators, respectively. In particular, these operators maintain abilities that allow them to at any time – when ordered to do so by Svenska kraftnät – reduce the power consumption in accordance with a demanded volume. This consumption reduction is to be effectuated within 15 minutes of receiving the order, and it should adhere to the prioritisation of the STYREL process as much as possible.

Collaboration and Networking alongside STYREL

The Swedish Energy Agency has the overall responsibility for the planning process. In this role, it has conducted a few personal group meetings with the CABs prior to the start of the process and a number of educational meetings for municipalities. In addition, national agencies are invited to participate in the planning. If a national agency does not have adequate knowledge of local circumstances or the operators of their assets, this agency may commission the municipalities to identify such critical infrastructure. Since participation is not mandatory, it remains uncertain for the Swedish Energy Agency and the CABs how agencies will participate if they choose to do so. This uncertainty complicated the proceedings at the regional and local levels. For example, the decisions of the agencies concerning health, postal services, telecommunication, defence and transport were a matter of concern for other actors in the process since the former refrained from participating and the latter interpreted the classification scheme in a particular way. Moreover, some national agencies did not follow the predetermined schedule, which led to further problems for the CABs. After the time was up, the CABs concluded that they would not receive further planning documents. Since they do not know which agencies will participate and send documents, they cannot remind them. It turned out that further documents appeared too late at the CABs, which caused a considerable delay, and both the CABs and municipalities ran out of time for their parts of the process. Therefore, the second run of the process was given an extended timeframe, which has been further expanded for the third run. Nevertheless, results from the research project indicate that the CABs perceived the collaboration with national agencies to be sufficient, even though 84.6 percent of them expressed a need for a more structured process for this activity, particularly to ensure a consistent interpretation of priority classes. As described above, each actor applies the scheme in Table 2 to classify their own infrastructure assets, which does not involve considering or taking other important functions in society into account. Since the proceedings were delayed and the process model did not require feedback, there was no nuanced discussion on the classification of critical infrastructures, which resulted in reservations regarding the trustworthiness of the national agencies' work.

The CABs are responsible for co-ordinating work with STYREL at the regional level. This role of the CABs proceeds alongside the main part of the planning process up until the distribution of the results to the power grid operators. Each CAB is expected to guide and mediate STYREL among the municipalities, even though the policy allows each CAB to determine the actual structure and organisation of the regional proceedings. As mentioned above, more than half of the individuals responsible at the CABs have not previously participated in STYREL, which suggests that knowledge in the system is stunted and that the CABs struggle in this role. Criticism has focused on the design of the STYREL reference process and process execution as well as on the limits regarding the usefulness of the resulting plans. During the research project, the evidence from the empirical study was dominated by several issues, such as an absence of feedback, the interpretation and application of the classification scheme in Table 2, the extent and quality of the resulting plan, the handling of information during the process and a feeling of insufficient support during and between the planning iterations. For example, discussions revolved around both the classification that each CAB had received from national agencies and sent to each municipality in its jurisdiction hosting such critical infrastructures and the identification and prioritisation carried out by CABs and municipalities at the regional and local level, respectively (Große, Larsson & Björkqvist 2021; Große & Olausson 2019).

Due to some changes in the planning process, CABs mainly used face-to-face group meetings to acquire more information and harmonise among municipalities regarding their planning results. In some counties, the municipalities and the CAB worked together more closely in a single group, whereas in another county, the CAB maintained four or five separate groups. Although this proceeding facilitated discussions for each group, it made it more difficult to obtain an understanding of the views of other groups and the region as a whole. As a consequence of this lack of relevant information and the variety of local interpretations, more than two-thirds of the CABs stated a preference for a more structured process with municipalities. This improvement may also include the last step of STYREL, in which the CABs merge all information from their municipalities and weigh in regional concerns. The weak regional co-ordination proposed in the reference process particularly caused the CABs to struggle with the proceeding in assembling the final ranking list due to unmoderated interactions and the absence of strategies for resolving conflicts. At this stage, the insufficient information nearly precluded an assessment of the preservation of local, regional and national requirements. About half of the CABs indicated that they merged the received information independently, and one CAB announced changes to the concerned municipalities. The remainder stated that they compiled the final list in co-operation with the municipalities. In general, the CABs appreciate the interaction with their municipalities and trust the quality of the municipalities' assessments. Moreover, the interviews revealed that the CABs draw on already existing networks ordinarily working with risk governance and crisis management.

The STYREL handbook encourages the national and local actors to involve private organisations in the identification phase as a substantial portion of critical infrastructures are privately operated. The suggestions include informing potential private actors and encouraging them to provide relevant information on the infrastructure they operate; however, the concrete proceedings are otherwise left to each public actor. This proceeding implies a time-consuming process, which according to the reports of several interviewees, exceeded the available resources. During the first run of the planning process, municipalities expended additional resources in terms of both working hours and training regarding the planning system. During the second run, municipalities did not allocate any additional resources, which implies that officials who participated in the first run of the planning enjoyed an advantage compared to those who only engaged in the second iteration. The study results also showed that officials from smaller municipalities tended to possess better knowledge of the activities in their respective municipalities compared to officials from larger municipalities. One reason may be that in smaller municipalities, an official may embrace a variety of responsibilities in a single individual. In addition, although the Swedish Energy Agency recommends gaining acceptance for the process at the upper management of municipalities, officials reported difficulties with regard to local governance of the process. Similar to the CABs at the regional level, the municipalities must adapt the general policy to local conditions to create a local setting and establish sufficient information paths (Danielsson et al. 2020). Dedicated resources and geographical conditions represent examples of the constraints that affected the concrete efforts of the local STYREL process. Hence, many municipalities were challenged by the involvement of the private sector as well as the integration of STYREL into local risk and crisis management. As mentioned above, the classification scheme was subject to extensive discussions and various interpretations and adaptions. For example, some actors developed their own lists of critical infrastructure assets that fit into each class or applied further sub-criteria, such as the turnover and number of employees of a classified operator of critical infrastructure or risk-enhancing geographical issues.

However, the results revealed that municipalities have almost exclusively focused on municipally operated critical infrastructures due to several reasons, such as the absence of interest from private companies and a lack of time and dedicated resources (Große 2020). Municipalities involve various sources in the identification process, including local registries and maps, individuals with special knowledge of local circumstances and, in rare cases, a local power grid operator.

According to the STYREL policy, the interaction between municipalities and local power grid operators is limited to the key elements of exchanging messages: a municipality sends a file to a power grid operator, which then completes the file with the requested information and returns it to the municipality. Municipalities and power grid operators experiencing the process reported that they largely organised their work in accordance with the reference process model. However, when it came to details regarding activities and information exchange, tensions arose with respect to areas of competence and responsibility. Both actors emphasise the need for more interaction and better quality in their co-operation. The results reflect a limited understanding of one another with regard to both daily operations and activities during the planning process. In some cases, the representative of a local-based power grid operator was part of the planning group and thus completely involved in the decisions on the basis of his or her expertise. In such circumstances, a mutual understanding of common goals and objectives developed during the collaboration, and the partners exchanged feedback. Such collaborations often occurred in pre-established local networks.

From the municipality's perspective, the number of local power grid operators varies. The spectrum of collaboration spans from very close co-operation with one operator – for example, since the municipality owns the grid-operating company – to formal correspondence with large providers located elsewhere. Interviewees experienced the latter type of contact to be less comfortable or, rather, that it was hard to co-operate with large providers. They also reported difficulties in terms of identifying a contact person in charge, particularly early in the proceedings, and an inability to establish a positive collaboration.

The perspective of the power grid operators is similar but different.

The three largest power grid operators are responsible for local grids in up to 120 municipalities. According to participants in this study, the sheer amount of data that these companies had to process during the recent planning impeded closer interactions. Another issue encountered by the larger companies during STYREL concerns data processing. In their role as operators of critical infrastructures, power grid operators are obliged to maintain a high information security standard. Hence, the information they receive from municipalities must pass through a security system using means such as sandboxing and encryption to prepare data from municipalities to use as input for their various computer systems. After completing the STYREL documents, they must be passed through the security system in the opposite direction. This workload alongside ordinary operations and in combination with strong information security requirements may also explain why power grid operators do not recognise a need to involve additional actors in the process. During the study, power grid operators expressed doubts regarding the quality of municipalities' work in identifying and prioritising critical infrastructures. In particular, the number of prioritised objects and their classification fuelled the debate over the adequacy of the result. Some power grid operators perceived the identification and prioritisation of critical infrastructure as being drastically different. Since most municipalities reportedly received no feedback about their work, this debate does not seem to have been transmitted to every participant in the process.

Although the STYREL handbook identifies the MFK planning as the final step in the process, it rather appears as subsequent planning, using the results of STYREL as constraints in the decision-making as much as possible while also considering technical feasibility. After the power grid operators have received their portion of the final list from the CABs, they are all legally obligated to perform their planning for a potential MFK and inform Svenska kraftnät and related CABs when finished. However, there is a weak commitment to report the fulfilment. One possible reason is the structure of the power grid. Local power grid operators rely on the power supply from the regional grid, which is typically operated by another provider. Some of the regional power grid operators, furthermore, operate some local grids themselves. Therefore, knowledge of local and regional circumstances varies. However, the results of STYREL consist of power lines in the local grid, which means that only local operators can employ these results in their MFK planning as intended. Thus, regional operators can only perform MFK planning in accordance with STYREL in the parts of the local grid that they operate themselves. Information on important power lines in subordinate power grids, to which regional power grid operators transfer electricity, is hidden at the regional level of the grid.

Another reason for the low completion rate may be related to the fact that only nine out of approximately 160 power grid operators fulfil the requirements to participate in the critical phase of an MFK. Since the results of the research project suggest that power grid operators hardly have any contact with each other with regard to MFK planning, some local operators may find this part of the process to be a waste of time. An alignment of the local and regional grid in this regard would need planning and interaction prior to an MFK. However, the STYREL process does not stipulate any co-ordination among power grid operators. In the current approach, there is no alignment between the MFK planning results nor any maintenance of close collaboration of power grid operators regarding STYREL.

Moreover, respondents from power grid operators reported that certain information alters the regional STYREL list. They noticed that certain power line identifiers in the CAB documents were not identical to the ones provided by power grid operators to the municipalities in the previous step or were actually missing. Such a lack of information may result in a failure to maintain an important line during a power shortage. Due to the design of the information processing alongside the STYREL planning, it is hardly possible for the power grid operators to track these changes. Explanations included that such errors could be the result of copy-and-paste behaviours, the use of outdated or incorrect data or even unintentional and unnoticed altering of information when municipalities, CABs or both edit the spreadsheet.

Maintenance and Development of STYREL

Some actors have documented key lessons from both the pilot and the two full-scale executions of the STYREL planning. Unfortunately, it remains unclear how these experiences have systematically influenced subsequent planning, as there is no systematic approach to system monitoring, learning and development. During the initial development phase starting in 2004, a reference group followed and reviewed the development of STYREL. This group, which was ended in 2011, included representatives from the Swedish Association of Local Authorities and Regions, Svenska kraftnät, the Swedish Civil Contingencies Agency, the Energy Market Inspectorate, the sectoral organisation Swedenergy, the Confederation of Swedish Enterprise, the CAB of Västernorrland and the municipality of Ludvika (SEA 2010b).

The results from the pilots at the local level revealed problems related to the prioritising of infrastructures, the planning process, the collaboration among participating actors and the need for improving skills and knowledge. The challenges surrounding the task of prioritisation mainly concerned difficulties in weighing important societal services against each other, the need for equal rules for conducting the task in all of Sweden and problems related to priority class 1, which were perceived as too broad. In addition, there was a need to clarify the planning process, establish proper project management in the municipalities and achieve adequate acceptance in the municipal management. Regarding collaboration, the municipalities participating in the pilot project emphasised their need for collaborating with key actors, especially power grid operators, and reported problems with 'unnatural municipal boundaries' when considering the local power grid perspective. Finally, the experience from the pilot demonstrated the necessity of clarifying and expanding the role of CABs in the entire planning process, including the tasks of identifying and prioritising critical infrastructure and the related collaboration (SEA 2008).

The evaluation of the pilot studies at the regional level presents similar results but also a few differences. For example, the regional level pointed to the importance of private-public co-operation in networks to enable the actors involved to identify and prioritise critical infrastructure objects. Proper engagement, however, presupposes that the representatives who are part of the network have clear mandates from their organisations. The evaluation further indicated a request for a digital tool meant to facilitate both the process of identification and prioritisation at the local and regional levels and the CAB's co-ordination of the large number of municipalities along with STYREL.

The research project confirms that many of these issues still persist and constitute obstacles to the further maintenance and development of STYREL. For example, since the reference process only specifies concrete proceedings poorly, many actors found themselves in a situation of conflict in terms of serving the objectives of two or more systems-of-systems to which they belonged (i.e., public or private organisations, co-operation networks and governance networks, etc.). At the level of individual decision-makers acting on behalf of a key actor, this conflict led to adaption, which reflects resignation, a fading commitment or learning from hearsay. As such adaptions accumulate over time, the Swedish system for identifying and prioritising critical infrastructures is likely to present an emergent behaviour during the next iteration of STYREL. Effects can emerge as, for example, changes in the participation of the particular actors, the amount of information provided or the dedication of resources. As indicated, contending with the complexity of the entire Swedish risk and crisis management system and the STYREL process creates a substantial level of entropy (e.g., evidenced by a lack of knowledge, high a level of uncertainty, resources that are used to define local proceedings and decision criteria), which compromises the effectiveness of the system in terms of producing a valuable emergency response plan. An increase in entropy over time (e.g., as a result of staff turnover and fading knowledge during long stand-by periods) tends to further reduce the effectiveness of the planning system and the efficacy of the process results for critical infrastructure protection. For example, the delay due to the Covid-19 pandemic and the war in Ukraine, as well as the related changes in the proceedings (see Figure 3), is likely to have a notable effect on the knowledge base of the participating actors. As indicated above, around half of the officials at the CABs, municipalities and power grid operators who participated in the research project had no experience with STYREL. Amplified by the time having passed since then and the long delay when it comes to the third iteration of the planning process, an increasing level of ignorance and unawareness is a serious matter of concern. As the results of the case study repeatedly illustrate, the scant attention to STYREL between the process iterations affected both the actors' awareness of the contextual framework and their interpretation of particular roles in this planning system. In addition, the commitment of actors and the knowledge and experience of this planning for critical infrastructure protection gradually diminished.

According to the evaluation of the first process iteration in 2010, the main challenge was to establish a shared view of the criticality of critical infrastructures and services in a region (SAE 2012). In an attempt to resolve these discussions while simultaneously strengthening information security, changes to the initial reference process model were made between the first and second process iterations. In the first iteration, the CABs had access to detailed information in order to participate more actively in assessing and balancing the priorities of the critical infrastructure assets at the county level. In the second iteration of the planning in 2014, CABs only received aggregated information to compile the results from the municipalities. This information exchange precludes any evaluation of the received information and co-ordination of cross-municipal or cross-regional requirements for the CABs. During the research project, the CABs thus expressed doubts regarding the usefulness of the planning outcomes for risk and crisis management. The municipalities emphasised that they require more feedback during and after the process in order to integrate STYREL into local risk assessments and emergency response planning. Nevertheless, both CABs and municipalities signalled considerable reservations regarding the extent to which STYREL is able to support the intended protection of society.

Moreover, municipalities reported another source of misunderstanding regarding critical infrastructure objects of regional or national importance. Specifically, they questioned the extent to which municipalities should consider the importance of critical infrastructure beyond its local borders, such as an airport. Such assets could have a higher priority at the regional or national level than at the local level. A similar problem occurs when a company located in one municipality in southern Sweden is of immense significance for other municipalities (e.g., in a county in northern Sweden) or vice versa. Since no formal information sharing is intended to apply between actors, it is not possible to evaluate the consequences of object classification at the local level in the current STYREL approach. Such a separate focus on a portion of important objects promotes an overvaluation of the infrastructure's criticality within the actor's own area of responsibility. The interviews indicate that such overvaluation has occurred at national agencies as well as municipalities, which has prompted recurring discussions on the matter. The fact that the official handbook opposes lowering the designated priority class by a subsequent actor in the process added more fuel to the conflict. Actors had a hard time finding a common denominator in their rankings, which, incidentally, is an extremely difficult problem due to the complex problem that the ranking is intended to structure. These discussions may exemplify the strategies used to individually define the problem, to make the critical infrastructures in their own area of responsibility 'look good' in the figures and to control how others will interpret the scores (Stone 2012).

Against the background of national regulations, the Swedish Energy Agency has the overall responsibility for STYREL, including its process, results and development. However, the approach delegates responsibility among the actors in the complex planning system, as apparent from the national regulation and Table 3. During the multi-organisation process, the Swedish Energy Agency provides the following support:

- A handbook describing the national policy for the approach
- Four planning spreadsheets one by one merging the data that the entrusted decision-makers should edit on a computer isolated from the internet
- User guidelines dictating the main functions of the planning spreadsheets and which actor should fill in which kind of data
- Preparatory meetings involving general information for key actors
- Short movies that exemplify the use of spreadsheets

Apart from these contributions in the initial phase of the process iteration, the Swedish Energy Agency does not perform system or process management and leadership activities nor any co-ordination at the national level of the process.

In general, STYREL lacks the proper means for assessing and comparing processed information, which, in turn, hampers future improvements. The perceived lack of feedback in combination with staff turnover during and between this large-scale and long-term planning aggravates the problem and causes adaption, emergence and entropy in the multi-level planning. Moreover, the absence of criteria for assessment, selection, success, quality, information security and performance complicates the evaluation of the entire process and its results. Although the small number of evaluations of the process development have already emphasised some of these issues, only limited changes have been made to the following policies. In addition, documentation of this improvement process or evaluations of the second round is absent, which suggests that such documents either do not exist, are classified or have not been released by their owners. None of the co-ordinating organisations or any central body collects any documentation or evaluation from the participating actors. The regulation explicitly refers to the Swedish Energy Agency, the Swedish Civil Contingencies Agency and the national power grid operator Svenska kraftnät as key actors responsible for the further development of the STYREL approach. However, the highly limited dedication of resources, the staff turnover and the specific system design also represent a challenge for the national actors. These issues obstruct not only improvements at the national level of the decision-making process but also further development of the reference process and the alignment of strategic objectives among the actors in the network and society. Many key actors lament the absence of a holistic, integrated view of STYREL and envision that integrating and altering the planning process might provide crucial benefits to the Swedish risk and crisis management system at subsequent planning levels, such as for the ones regarding preparedness and contingency planning.

The analysis indicates that different interpretations of vague descriptions and implicit objectives prompt different proceedings. Strategic objectives are numerous, highly diverse and will occur simultaneously due to the number of actors and stakeholders in the Swedish risk and crisis management system (Große 2018a, 2018b). Thus, uncovering tacit content and its significance can assist in converting objectives, which, in turn, may facilitate the development of STYREL. Due to the current design of the proceedings, the results of the STYREL planning rely on the commitment of the CABs to achieve a common understanding of the criticality of infrastructure and for mediating collaboration in their geographical area of responsibility. The level of trust between the different actors seems likely to further influence the resulting emergency response plan, which signifies the chain of policy, interaction and learning between the public and private actors, such as national agencies, CABs, municipalities and power grid operators, alongside the process. Current circumstances introduce additional uncertainties due to a lack of knowledge, which includes poor awareness of activities, differences in interpretations of the criticality of infrastructure and varying degrees of maturity of the activities of actors. Such flaws intensified individual prejudices rather than alleviating them, which led to an extensive variation in levels of mutual trust and respect between actors. The consequent increasing entropy in combination with a growing system of critical infrastructure necessitates appropriate governance, management and leadership efforts to channel the dynamism of this complex system.

Further development might clarify the activities and responsibilities within the system, which is entrusted with not only STYREL and risk and crisis management but also civil defence, as well as improve resource allocation at the local, regional and national levels. Moreover, clarity in horizontal and vertical structures might reduce knowledge gaps. Evidence from the empirical inquiry into the Swedish case can direct such governance efforts as the experienced conditions of the current setting indicate areas of improvement, such as collaboration within and between organisations, interaction and communication alongside the planning and understanding the possible situations that the planning targets. In view of the discussion above, development efforts in the context of STYREL are encouraged to address the following:

› Raising awareness of the complexity of the risk and crisis management system
› Assessing key actors and their roles, responsibilities and accountability
› Identifying and analysing the interdependencies and structures regarding tasks, processes and organisation
› Establishing and maintaining a consistent overall system framework in terms of scope, level of granularity and participation
› Identifying strategic objectives and hidden perceptions in the networks
› Assessing strategic objectives in terms of relevance and feasibility
› Involving additional societal actors and co-ordination of all actors
› Risk and impact analysis (as well as further emergency power supply)
› Prioritising and integrating objectives, goals and means
› Communicating and controlling preferred strategic objectives
› Visualising structures, interrelations and individual conditions
› Aligning responsibilities and information security measures
› Developing the reference process and resource allocation

- Developing the decision-making processes and the available support
- Assessing the suitable granularity of the processed information, the adequacy of access rights and the appropriate information paths
- Collecting and presenting learning cases of good practices and pitfalls
- Collective learning: training, feedback and knowledge exchange
- Establishing particular parameters to enable regular evaluations of particular aspects, such as selection criteria and success factors
- Transferring the STYREL planning results to next-level planning
- Aligning STYREL with preceding analyses and subsequent planning, such as risk and vulnerability analyses and contingency planning
- Enhancing mutual trust, respect and understanding between actors
- Developing policies, process management and system leadership

After analysing the multi-level governance system entrusted with STYREL, the following chapter discusses a few of the issues listed above in more detail and seeks to trace how these could be further managed. However, the process of exploring, designing and evaluating solutions was not part of the underlying research project and is thus beyond the scope of this book. Further research is needed to support a continuous improvement of the STYREL planning and to analyse the longitudinal effects of the approach on the Swedish crisis management system and vice versa.

Key Challenges for Societal Security

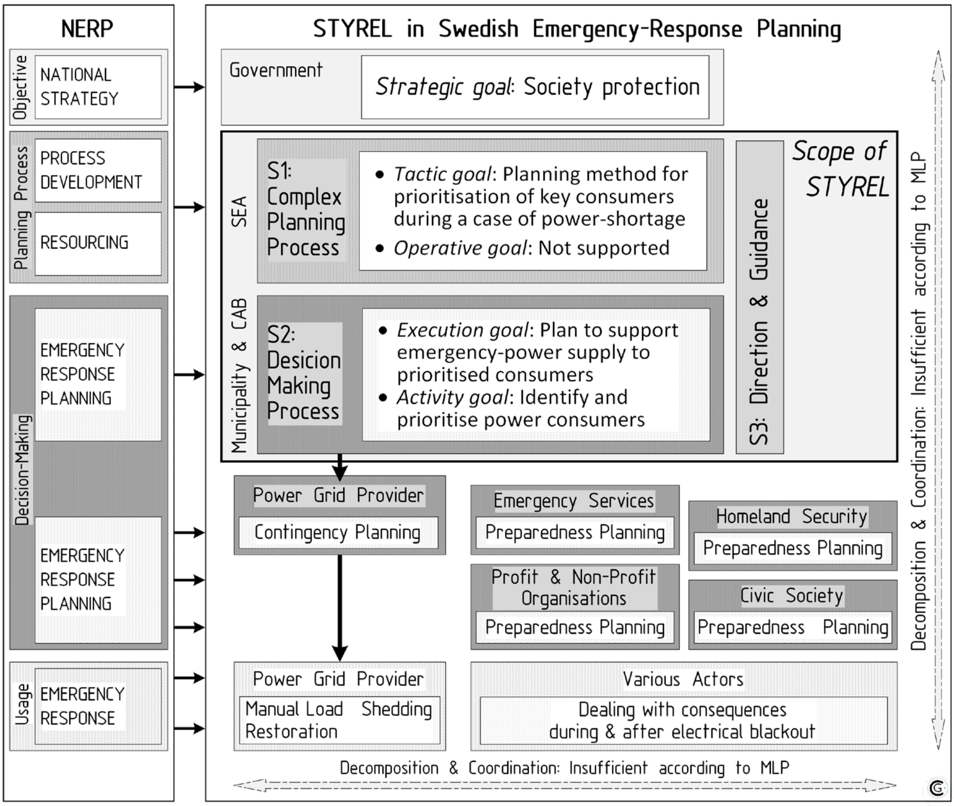
TO CONCLUDE THE BOOK, this chapter addresses the third question of this report: which challenges does STYREL have to contend with and how may these be addressed within the Swedish risk and crisis management system? The chapter discusses a few current challenges interrelated with STYREL and discusses how these could be further managed within the Swedish risk and crisis management system.

Critical infrastructure protection is a societal concern involving a large-scale system of public and private actors in certain activities to mitigate the negative consequences of disturbances in infrastructures and services that are essential for society. This concern involves, for instance, long-term planning for maintenance, emergency response and risk and crisis management. Since electricity has become a key element in society, the main focus of critical infrastructure protection is undisturbed power supply for critical infrastructures, which also plays a key role in the Swedish STYREL. The previous chapters revealed numerous challenges related to societal security and efforts of public-private collaborations to ensure the proper functionality of critical infrastructure in society. The identified challenges related to STYREL are linked to the three levels of a multi-level planning approach:

1. The Swedish risk and crisis management system
2. The identification and prioritisation of critical infrastructure
3. The utilisation of the resulting ranking list

First, challenges associated with the risk and crisis management system refer to integration, resourcing, co-ordination and guidance. As

Figure 5. Sources of uncertainty according to STYREL.



NERP: National emergency response planning; MLP: Multi-level planning.

depicted in Figure 5, the approach is currently not well-integrated, which is why many key actors lament the absence of a holistic, integrated view of STYREL. Instead, they envision that integrating and altering the planning process could provide a crucial benefit to the Swedish crisis management system at subsequent planning levels, such as the ones for preparedness and contingency planning. As a part of this, actors at the local and regional levels require a clearer connection to the RSAs. This would facilitate a clearer quality assurance and support STYREL with more general analyses of risks and vulnerabilities within the geographical area of responsibility of CABs and municipalities.

Another issue is that this long-term planning alternates with long stand-by periods between process iterations, during which relevant individuals change work tasks or positions. Organisational knowledge and experience of the proceedings consequently vanish, which has been insufficiently accounted for in the governance. Clarity of objectives, goals and means thereby diminishes and warrants completely new considerations in the next process iteration. During the research project, which took place after the second iteration of the planning process, it became apparent that many decision-makers had no personal experience with STYREL, which can be both problematic and beneficial. In terms of the former, it can lead to 'copy-and-paste' behaviours, whereby an inexperienced, overworked and lonely decision-maker relies on documents from previous planning efforts and simply finishes the task. In the latter, it may prompt curiosity and commitment, so that the decision-maker is eager to learn and gain knowledge in order to prepare for the planning. The importance of addressing learning and subsequently transforming experiences into future behaviours is a significant task for higher-level governance, and it must not be underestimated. Otherwise, the shared reality based on the experiences of other members in the network could profoundly influence individual judgements. Since experience levels have been inadequately addressed, decision-makers in the distributed approach in Sweden must rely on their own perceptions and determinations of proper local proceedings. Individual adaption can thus trigger an emergent system behaviour during the next process step or iteration or subsequent preparedness planning. The findings from studying the Swedish case highlight the need for thoroughly considering the various interests involved in such a complex system of national multi-level planning. Even though the large-scale approach to critical infrastructure protection against power shortages involves many actors, it largely fails to involve the private sector and neglects to stipulate further participation from non-governmental organisations or citizens to enhance the resilience of society. The analysis further highlights the ambiguity in several steps of the process, such as the designation of information paths and that expected efforts and responsibilities remain unclear. Thus, this proceeding results in uncalculated consequences. For example, the guidelines did not adequately specify process events, which meant that partners in an interaction often had to wait for one another to then receive a message or document that differed from what they expected. Information flaws and impersonal interactions intensified individual prejudices rather than alleviating them, which led to extensive variety in levels of mutual trust and respect between actors. The current design of the approach hampers transparency and evaluation, which poses obstacles to the cultivation of mutual trust, collective learning and a shared understanding as well as proper risk communication with the broader public. Despite a repeated call for collaboration and co-ordination during crises, studies have revealed that cross-functional co-operation results in frustration and several problems due to inadequate information paths, organisational biases and a lack of mutual understanding. Such issues are not only linked to the management of a particular crisis, but they can also be experienced in the context of risk governance and preparedness planning processes, such as STYREL.

Second, challenges associated with the decision-making process refer to the identification and prioritisation of critical infrastructures at the local, regional and national levels and the co-operation to achieve a structured policy. The analyses reveal that the majority of decisions at a municipality or CAB during the decision-making process of planning for STYREL are made solely by one person who is responsible. This raises high demands in terms of both the decision aid provided and the characteristics of a decision-maker tasked with the planning. Although many of the interviewed decision-makers found the technical support via spreadsheet files to be acceptable, they raised issues regarding its clarity, compatibility, functionality and ability to ensure information security. In addition, decision-makers encounter various planning activities during their everyday work, which require proper preparation prior to the decision-making regarding the ranking of critical infrastructure. However, the current planning approach lacks co-ordination of similar planning activities. Reusing and planning the local process is delegated to people who are locally responsible and who experience this as an inappropriate burden that necessitates a great deal of individual engagement and dedication of local resources. However, the results, especially from the first planning iteration, reported that the information collection during the inventory of critical infrastructures is problematic and time-consuming. Much effort had to be invested in discussions with internal and external stakeholders to identify relevant societal functions and electricity-dependent infrastructures, which resulted in almost no involvement from privately or non-governmentally operated critical infrastructures. A particularly difficult aspect is the classification of each identified power consumer with the aid of the eight-class scale (see Table 2), which requires assessing a consumer's importance to the local society. The results revealed that actors tend to classify all assets of the same type as equally critical in accordance with this scale, regardless of the impact of each object on the surrounding society and without further selection. Considering a power shortage situation, such insufficient selection can cause a power consumption reduction that affects prioritised consumers. In addition, this local perspective ignores interregional or even global interdependencies, such as critical supply chains.

Moreover, to complete the ranking locally first and then regionally, the spreadsheet files currently in use execute a cumulative calculation, which can be seen as inadequate and highly questionable. The spreadsheets intentionally effectuate information withholding, which has been motivated by information security concerns as well as recurring discussions of variations in how agencies and municipalities interpret the priority list. This adaption of the planning process, which may also be considered a result of the politics of numbers (see chapters 3 and 4), affects the granularity of information, which is why the consequences of the classification at the local level cannot be evaluated. As a consequence, officials at municipalities and CABs experienced a lack of knowledge concerning the quality and usability of their results to represent a challenge during the planning. As mentioned above, network governance is based on the idea of trusting co-operation between actors of public and private sectors, which identify the need for co-operation and thus commit themselves to a specific co-operation and share information with other actors within the network. In the case of STYREL, the study has revealed a lack of trust in the general approach, which affects the actors when engaging in co-operation. This lack of trust causes individual adaptation processes, which, for example, in the analysed case emerged for other actors as a *copy-and-paste* behaviour. The study reveals several information-related issues, such as unintended ones similar to playing telephone through the process and the intended information suppression between some of the planning steps (see Figure 4). Although the STYREL handbook advises an accumulated regional ranking for all power lines, it does not propose how the importance of critical infrastructures should be balanced between municipalities and regional or national interests. Similar to the difficulty of CABs in creating a regional ranking list in view of information scarcity, power grid providers operating many local grids in numerous regions face a comparable challenge in compiling the lists they receive from the CABs in such a way that they match power grid areas. The STYREL reference process does not stipulate any approach for this collocation and leaves this decision up to the power grid operators. In addition, the STYREL reference process, as well as one of the options for round three, suggests an occasional annual revision, which seems impossible in light of the information being created, lost and altered during the proceeding. Such information filtration and altering affect the outcome of the planning and, in turn, the consequences for society when such a plan must be operationalised during a power shortage.

Third, challenges associated with the utilisation of the developed plan refer to subsequent preparedness and continuity planning, emergency response and societal security. The final plan, which emerges as aggregated ranking lists by the county at the national power grid operator and in portions at each related power grid operator, does not contain any information on critical infrastructure objects. It contains the name of the county, the local power line identifiers, the power grid region and a ranking number for each line. The only actors able to use these final lists are the local power grid operators, which are legally obligated to use them in their MFK planning, as illustrated in Figure 5. As detailed in the previous chapter, the power line operators have to contend with a number of technical, economic and organisational challenges when implementing the results of STYREL. Another issue is linked to the conflict between the relatively dynamic power grid expansion aimed at developing transfer capacity to meet society's growing demand for a stable power supply and the relatively static STYREL planning with long stand-by periods. In the period until the plan is updated, changes in the power grid structure alter the interconnection of power lines with critical infrastructure objects. The estimated loss concerns approximately 3 percent of an operator's power lines per year, which possibly prevents the prioritisation of important power consumers in case of power shortages due to information scarcity. The delay in the next round of planning and other issues discussed above have the potential to aggravate the effect of such a loss in case of an emergency.

Further use of the identification and prioritisation of critical infrastructure in subsequent planning is not offered in the current approach and is left to local initiatives. Due to limited resources and knowledge paired with no available feedback during the planning process, the participating actors cannot completely rely on their results as input for further contingency planning (e.g., considering reserve power or evacuation strategies). The current proceedings, therefore, decrease the ability of municipalities to execute their responsibilities in a crisis, since they are not involved in the later steps of the planning process and thus do not get any feedback on which, if any, power lines will be prioritised during a power shortage. This creates a parallel logic to the one described in the Swedish crisis management system, and it complicates the municipalities' ability to act in case of a power shortage or outage, which can occur simultaneously with other events, such as flooding, snowstorms, wildfires or pandemics.

In addition, the recent planning hardly involved large segments of society, and neither non-governmental or private organisations nor households were involved, as such proceedings had surpassed the municipal capabilities. Nevertheless, this absence implies that the majority of privately-operated critical infrastructures are not properly represented in the plan. Many municipalities mention the STYREL planning on their websites, which can be seen as an attempt to address this exclusion. However, the insights from the planning should inform the development of proper risk communication to the broader public to enhance the awareness and preparedness of companies and individuals, which, in turn, could support a level of resilience in society as suggested by NATO.[13] The plan resulting from the STYREL process further obscures an appropriate consideration of infrastructures that are critical from a regional, national or international perspective. Thus, unexpected, potentially severe consequences are likely to emerge suddenly in case of a power shortage, which then urge ad-hoc proceedings in times of national crisis management.

13. https://www.nato.int/cps/en/natohq/topics_132722.htm

The war in Ukraine has not only raised public awareness regarding energy, food, raw material and product supply, but it has also intensified the debate about military and civil defence, which very recently (2022) culminated in Sweden and Finland applying for NATO membership.14 Against this backdrop and an increasing risk of natural hazards due to climate change, Sweden has further accelerated its efforts to strengthen its total defence, which presupposes co-operation and collaboration from a large number of actors, essentially embracing the entire society (Prop. 2020/21:302020). This proposition states that civil defence should, as far as possible, be based on structures and processes used in the risk and crisis management system. Without discussing further details, we see that military defence mainly applies a command-and-control structure, whereas the risk and crisis management system relies on a co-operation-and-collaboration approach. A considerable task will be to align these perspectives and modes of steering and operation. The proposition further requires that 'structures, processes and working methods that have not proved appropriate and which are not sufficient for handling heightened preparedness' need to be updated during the period 2021–2025. (Prop. 2020/21:30). This requirement should be understood as an additional request to further develop STYREL and its integration into the Swedish crisis management system and alignment with RSAs and total defence planning (Große & Gunneriusson 2020).

To begin with, it should be acknowledged that co-operation and collaboration in governance networks require an allocation and dedication of resources, such as in form of personnel, working hours and competence as well as technical and methodological means. However, this requirement applies not only at the local level but also at the regional and national levels in order to improve interactions horizontally and vertically in the risk and crisis management system. In this regard, it is worth noting that in many organisations (at all levels of society), the single person entrusted with societal security issues often works only part-time with interrelated tasks, which hampers further co-operation and collaboration in governance networks. This also relates to the challenges of accountability in the governance environment. The design of

14. https://www.government.se/government-policy/sweden-and-nato/swedens-road-to-nato/

STYREL, including the lack of feedback between the different steps of the process, contributes to this issue since municipalities do not know which power lines will finally be prioritised. Hence, municipalities find it hard to take responsibility for the consequences of the planning.

Another matter of concern is who will be viewed as accountable if an important object is not supplied with power during a power shortage. Is it the municipality that made the first identification of critical infrastructure and the power lines supplying them? Is it the CAB that merged the lists from the county's municipalities knowing very little about the objects along the lines? Is it the power grid operators who finally decide which lines will carry current and which will be disconnected? Is it the Swedish Energy Agency that is entrusted with both ensuring the security of supply and developing and co-ordinating society's emergency preparedness in the field of energy? However, the STYREL process makes it difficult to hold any actor accountable for the effects of the planning.

As mentioned above, a resilient society is a requirement for membership in NATO. The STYREL process, as part of the Swedish crisis management system, represents an important approach for ensuring a reliable power supply for critical infrastructure. In addition, its proper function is not only essential for mitigating new threats, which may occur as a result of the NATO application, but also for meeting the demands of industries. Thus, to ensure a reliable power supply to planned and newly established energy-intensive industries, there is a need for a reliable risk governance and crisis management system, targeting societal security and civil protection in general and a reliable power supply in particular, even during a power shortage.

Another area of improvement should strive for enhancing mutual trust, respect and understanding between the actors in the Swedish system. One aspect is to increase people's awareness of the complexity of the risk and crisis management system in society. As we can learn from the Covid-19 pandemic, society adapts and develops even during crises, which makes it difficult to anticipate and prepare for all possible futures. Uncertainty is a key symptom in the context of risk and crisis management as various interdependencies influence planning and response. Hence, prescribing actions before, during and after such a future event is a complex endeavour. Such multi-organisational planning requires decomposing and co-ordinating goals and means throughout a multi-level approach. Such a systematic proceeding is necessary for enabling decision-makers or other actors responsible for risk governance and critical infrastructure protection to reduce their subjective interpretations and act in line with agreed-upon goals for societal security. Another aspect is to improve collective learning through dedicated training, feedback during planning tasks and exchanging knowledge with other professionals. Such exchanges of knowledge should involve not only experts entrusted with the same tasks but also people from other levels in the risk and crisis management system, different public sectors, industries and universities in order to expand the actors' perspectives. Therefore, individual and group training could include idealised cases of good practices and pitfalls with the aim of developing creativity and improvising as well as problem-solving capabilities.

Finally, as the analysis in this book has repeatedly emphasised, there is a considerable need to further develop the STYREL policy and the interrelated risk governance, process management and system leadership to enhance societal security and resilience. Here, there needs to be a particular focus on cyber security that not only refers to the confidentiality of information but, just as importantly, addresses the integrity of information and its availability to entrusted users whenever needed. Inter-organisational information management between actors is particularly important for critical infrastructure protection, wherein information security and information sharing represent important yet conflicting aspects. In the case of STYREL, this is an issue in the collaborations, such as between municipalities, CABs and national agencies when identifying critical infrastructure and between power grid operators of local and regional grids when planning for and effectuating an MFK.

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When demand for electricity is greater than what is currently possible to produce or import a last resort is to disconnect consumers from the electricity system in order to maintain the balance of the system. When and how such a manual disconnection takes place is based on a national planning system, coined STYREL.

The authors provide a thorough review of the national planning process. They describe the responsible actors, how critical electricity users are identified and prioritised, and provide guidance on how to improve the planning process.

Pär M. Olausson is associate professor of political science and researcher in Risk & Crisis Research Centre at Mid-Sweden University, Östersund.

Christine Große is assistant professor in information system and researcher in Risk & Crisis Research Centre at Mid-Sweden University, Sundsvall.

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