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Sources of uncertainty in Swedish emergency response planning

Christine Große

Department of Information Systems and Technology, Mid Sweden University, Sundsvall, Sweden

ABSTRACT
With the growing importance of enhancing modern society’s resilience, planning for critical infrastructure protection has become essential. However, such national planning must contend with many types of uncertainty. This paper characterises sources of uncertainty that are associated with a lack of knowledge, as exemplified by Swedish planning of emergency power supplies. The planning under investigation concerns civil protection from the negative effects of a power shortage. A decision process is intended to support this national strategic management goal by identifying and prioritising electricity consumers who are critical to society at the local, regional and national levels. The analysis of related documentation yields three sources of uncertainty (S) interrelated with this multi-level planning (MLP) for emergency response: (S1) the planning process in general, (S2) the decision-making process in particular and (S3) the direction and guidance alongside these processes. Interviews with decision-makers reveal a detailed specification of these sources of uncertainty. The results thus provide a solid basis for further goal-directed improvement of national MLP approaches. Moreover, this specification contributes to scholarly debate on the systemic effects of sources of uncertainty due to a lack of knowledge. Lastly, the findings constitute a thinking framework that is suggested as a foundation for analytical work in similar complex planning environments as well as for evidence-based communication to the wider public concerning risks and resilience.

1. Introduction
Uncertainty is a key symptom in the context of national emergency response planning (NERP) for electrical blackouts because various interdependencies influence this planning. NERP is therefore a complex endeavour to prescribe actions before, during and after such an event in the future (Comfort 2007). Although NERP focuses on actions for responding to an event, the boundaries between prevention, preparedness and emergency treatment are fluid. Aside from thorough consideration of possible events concerning the probability of occurrence and expected damage, planners make strategic decisions with respect to the societal, political and technical demands that the consequences of a power shortage may pose for interdependent infrastructure that is critical to society (Kolen and Helsloot 2014; Rinaldi, Peerenboom, and Kelly 2001). Planning for critical infrastructure protection (CIP) therefore physically and politically affects not only local populations but also larger populations, even across national borders. These conditions result in complex planning environments that are ambiguous and incoherent due to the interdependencies that are involved, whereby a lack of knowledge intensifies the uncertainty. This
uncertainty correlates with elements of multi-level planning (MLP) of NERP. Decomposing a complex NERP for CIP into its hierarchical levels introduces the sources of uncertainty to a deeper analysis and facilitates a detailed specification.

The motivation behind this study is to provide insight into strategic management in practice, particularly in complex planning situations such as the NERP for CIP (Bryson, Berry, and Yang 2010). The paper therefore aims to identify and characterise sources of uncertainty associated with such planning in order to inform further improvements to the interrelated national processes (van der Vorst and Beulens 2002).

For this purpose, Swedish emergency response planning is approached through the following question: How can sources of uncertainty be identified and characterised within the planning for CIP with respect to power shortages? In Sweden, the NERP approach to power shortages was developed between 2004 and 2011 and is based on investigative studies on control and collaboration among municipalities via network models (Fell 2008). The Swedish planning is anchored in local communities because it assumes that individuals responsible at this level are knowledgeable about infrastructure of local importance, which constitutes the crucial input information for this NERP. Besides local actors, which include municipalities and power-grid operators, regional actors such as county administrations and national actors such as national agencies also participate in the planning outlined in Section 4.1.1. The Swedish approach plans a response to presumed cascading consequences due to interdependencies between the electrical system and infrastructure of national importance (Rinaldi, Peerenboom, and Kelly 2001; SEA 2014). Since Sweden applies planning for power shortages that scientific literature suggests is unique, the results of this study could offer a new perspective of NERP for CIP and provide valuable insight into process development in similar contexts.

Following this introduction, Section 2 applies the foundations of MLP to NERP in order to limit the scope and uses parameters related to uncertainty in planning and decision-making to define the depth of the present study. Section 3 describes the data collection and analysis through the comprehensive document and interview study. Section 4 presents both the MLP-associated sources of uncertainty identified during the document study and their specification by parameters using evidence from meetings with decision-makers. Section 5 discusses how the study can inform an evidence-based improvement of NERP for CIP in the Swedish and similar contexts and indicates implications for research and practice. Section 6 concludes the study and suggests further research inquiries.

2. Uncertainty in planning for critical infrastructure protection

2.1. Emergency response planning as multi-level planning

NERP for CIP entails planning at multiple levels and involves actors from both the public and private sectors. Historical advancements of MLP approaches and practical implications for production environments have influenced such public planning efforts (for detailed background information, see e.g. Bache and Flinders 2004; Bryson, Berry, and Yang 2010; Fuchs 1997; Howlett 2009; Scheer 1980; Schmidt-Assmann 2006; Sicilia et al. 2016; Winter 1991). Rizvi (2014) has recently demonstrated how a planning approach can impact outcomes and has argued for integrating the implementation process into planning. Although considering a plan’s benefits during planning improves the outcome, such integration can be difficult in NERP due to its multi-agency-planning character (Alexander 2015). Therefore, such multi-agency planning requires decomposition and co-ordination of goals and means throughout a multi-level approach. Hence, as follows, this paper suggests a separate consideration whilst maintaining a holistic perspective in order to meet the complexity, uncertainty and ambiguity associated with the systemic nature of this MLP.

MLP has three major characteristics: (1) differentiation of hierarchical levels, (2) decomposition of an overall issue into single problems and (3) co-ordinated solution of these single problems. MLP is a means to cope with complex problems and results, ideally through a plan which can be executed and monitored (Allouche and Berger 2011). These properties to structure a NERP for CIP are presented in detail below:
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 and Wilhelm 2000). These planning perspectives generally consider the planning stages before a production process, and in this paper they 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) – produces a plan and thereby completes one level within a decomposed MLP approach. Subsequent planning levels use higher level plans as input. Implications related to a produced plan and its further usage – utilisation of the result of planning (C) – are particularly important in the public sector due to conceivable national-economic and societal 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, Crosby, and Bloomberg 2014; Schedler and Siegel 2005).

Decomposition of complex planning tasks into single problems entails concretising goals and means during processes (Huber 2014), while goals and means of lower level processes must conform to interconnected higher level ones (Munro, Liaskos, and Aranda 2011) visualised by arrows in Figure 1. Otherwise, goal conflicts can affect decision-making and motivation (Stasser, Kerr, and Davis 2015), which can further impact a plan’s benefits.

Co-ordination occurs in two directions, which are represented by arrows in Figure 1: horizontal, alongside a process, and vertical, across organisational structures companioning hierarchical constructions. This co-ordination provides a basis for achieving efficiency and effectiveness during processes. Thus, in addition to concretely defining communication paths and relevant documentation, attention must be directed towards leadership efforts, guidance and direction throughout established structures (Bryson, Crosby, and Bloomberg 2014).

This structure is applicable both to the entire planning for CIP from an aggregated perspective and to each hierarchical level within a decomposed MLP. This facilitates an adjusted examination that is

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Figure 1. Characteristics of MLP applied to national planning for emergency response.
similar to an alignment of goals and means throughout national (or international) planning. Figure 1 summarises the previously described correlations, which constitute one part of the theoretical framework underlying the study below.

The discussion above reveals a need for communication and collaboration among the involved actors in order to cope with uncertainty which arises 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.

2.2. Uncertainty in planning and decision-making for critical infrastructure protection

Characterised by an orientation towards construction (of new states), planning applies a future perspective and intensively processes information and results into a plan to achieve a preferred new state (Wild 1982, 12–15). Hence, planning is associated with uncertainty in several ways. In order to move towards a preferred new state in the context of planning for CIP, one concern is how to properly assess the criticality of infrastructure (Fekete 2011). This concern includes questions about interdependencies between infrastructure assets as well as which consequences emerge, and for whom, after a critical event. For instance, the case of a critical power shortage is likely to provide cascading effects that pose severe consequences for society (Hines, Balasubramaniam, and Sanchez 2009; Vaiman et al. 2013). Therefore, an estimation of the consequences of future power shortages during planning stages must take into account the interests of concerned stakeholders, such as the national government, public and private organisations, and civic society and individuals (Aven and Renn 2009). Whereas many studies have estimated economic loss that is directly interrelated with an outage (de Nooij, Lieshout, and Koopmans 2009; Shivakumar et al. 2017), few have addressed consequences for households during a crisis (Ghanem, Mander, and Gough 2016) or the after-effects that occur, such as an increasing population (Burlando 2014). Assessing these interests with regard to the values that critical infrastructure maintains for a respective part of society can address demands in order to plan an appropriate emergency response.

A systemic risk assessment regarding critical infrastructure’s current and preferred states is required, e.g. by the European Commission (Giannopoulos, Filippini, and Schimmer 2012; Theocharidou and Giannopoulos 2015), for preparing planning that intends to mitigate negative or undesirable consequences (CFRA 2015). However, the central role of the power distribution system in a complex system of critical infrastructure makes it difficult to quantify the risks that result from the cascading effects of power outages (Pescaroli and Alexander 2016; Rinaldi, Peerenboom, and Kelly 2001). These risks, which are systemic in nature and intertwined with the cascade effect, hamper a quantification due to increasing complexity, uncertainty and ambiguity (Renn 2016). Therefore, holistic planning for CIP includes several perspectives, and the Swedish approach as multi-agency planning involves actors from local, regional and national authorities and organisations (Große 2017).

Aside from critical events and their consequences, uncertainty in NERP for CIP also relates to the planning and decision-making process. Since the effects of decisions are initially unclear, it is challenging to perform a conventional risk assessment early in the planning. This phase envisions risk as a concept that is posed by uncertainty about the consequences of planning activities (Aven, Renn, and Rosa 2011). Although the consequences of the Swedish STYREL planning have not yet been evaluated via a risk assessment, side effects for other local risk assessments are apparent. This may illustrate the complexity of NERP for CIP which, apart from uncertainty stemming from stochastic effects, also involves several sources of uncertainty associated with knowledge gaps.

NERP for CIP further involves individuals who act on behalf of an agency or organisation (decision-maker), who may also collaborate in planning groups that represent larger or different agencies and organisations (decision group). Klein and Scholl (2012, 2) have argued that ‘Planning is a [...] based on (mostly) incomplete information performed by planners for solving decision problems under consideration of subjective representation of goals’. As mentioned, the respective goals of new preferred states must be clearly communicated alongside the MLP. This enables the decision-maker or group
responsible for NERP for CIP to reduce their subjective interpretation and act in line with national goals for civil protection. However, the study below indicates that the aforementioned intensive processing of incomplete information and decision-making based upon it can challenge decision-makers at Swedish municipalities and county administrations in the MLP approach. Furthermore, group settings may include concerns that increase individually perceived uncertainty, e.g. a decision-maker needs to pay greater attention to prevalent group values, the ambiguity of information that can emerge and the feeling of being forced into action, i.e. making the decision (March 2002). Stasser, Kerr, and Davis (2015) have demonstrated that group decisions, whether joint or distributed, can be vulnerable to such behaviour, and they tend to assign trust to the opinions of experienced group members, implying that not all alternatives are appropriately considered.

Hence, the deliberations above impel an elaboration of the sources of uncertainty that are associated with planning for CIP. Such a MLP environment can be surveyed by questions such as the following: To what extent does knowledge exist about (P) (where P is a parameter)? Table 1 displays parameters derived from the discussion above, which constitute the other part of the theoretical framework applied in this study.

### 3. Methodological approach

#### 3.1. Framework for analysis

This study explores a Swedish response planning and investigates interrelationships between uncertainty and planning activities. To enable this, sources of uncertainty were extracted from the Swedish case by applying the MLP concept presented in Section 2. Thereafter, the parameters discussed above fostered the more detailed analysis and specification of these sources of uncertainty, which stem from a lack knowledge. This theoretical framework guided the data analysis during both the intensive document review and the interviews with decision-makers responsible for the planning.

The document review analysed publically available Swedish descriptions of the planning approach, such as guidelines, regulations, national laws and reports on the national, regional and local levels. Thereby, sources of uncertainty emerged, as emphasised in Section 4.1.2. These sources of uncertainty, in combination with the aforementioned parameters, structured and further guided the meetings with planners at municipalities and county administrative boards (CABs), as discussed in Section 4.2. The intention was to specify the identified sources of uncertainty by applying both the parameters from the

<table>
<thead>
<tr>
<th>Parameter (P)</th>
<th>Understanding facilitates…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Events and consequences</td>
<td>Context-based sense-making processes and goal-oriented planning</td>
</tr>
<tr>
<td>Chains of cause and effects</td>
<td>Combined prevention, preparedness and treatment planning</td>
</tr>
<tr>
<td>Characteristics of a decision-maker</td>
<td>Supporting individuals bearing their individual levels of experience, personal values, norms and risk affinity</td>
</tr>
<tr>
<td>Controllability</td>
<td>Balancing structures, objectives and constraints</td>
</tr>
<tr>
<td>Goals and future perspective</td>
<td>Target-oriented process development</td>
</tr>
<tr>
<td>Means and pathways: (Individual vs. Group)</td>
<td>Developing efficiency and effectiveness, organisational learning and training, and collective intelligence</td>
</tr>
<tr>
<td>Process system and rationale: (Individual vs. Group)</td>
<td>Reducing goal conflicts and confusion with respect to responsibilities and formal settings</td>
</tr>
<tr>
<td>Information processing</td>
<td>Evaluations regarding quality of data, its usage and its impact on planning activities, and technical support</td>
</tr>
<tr>
<td>Alternatives and preferences</td>
<td>Objective and rational decision-making</td>
</tr>
<tr>
<td>Consequences and interdependencies</td>
<td>Goal-oriented decision-making; documentation further supports organisational learning and training</td>
</tr>
<tr>
<td>Information procurement and communication</td>
<td>Assistance in systematic decision-making and interpreting the quality of data and its impact on the quality of the decision</td>
</tr>
<tr>
<td>Decision-makers and their (working) environment</td>
<td>Noticing cognitive limitations, formal settings, social issues, inadequate guidance and space (time, capacity, creativity)</td>
</tr>
</tbody>
</table>
literature and the insights from decision-makers who perform the planning in practice. The interviews concretised the applied parameters and related them to the sources of uncertainty. During this course, further factors were identified which influence the sources of uncertainty. Section 4.3 synthesises these interrelations.

3.2. Meetings with decision-makers

The results of the literature review and document analysis formed the basis for the empirical interview study. During this part of the study, semi-structured face-to-face interviews were personally conducted with 18 responsible individuals at all municipalities of two regions and their respective CABs. The interviews lasted one hour on average and were recorded and transcribed. A questionnaire with open-ended questions, which was based on the aforementioned sources of uncertainty and parameters, was employed as a guide to ensure a similar structure in each interview as well as to allow participants to report on individual experiences and perceptions. Follow-up questions were asked to achieve more clarity and richness of detail. This yielded a thick description of local and individual proceedings.

The visited regions are distinguished geographically: one is located in the northern part of Sweden and one in the eastern-middle part. Although the number of municipalities is almost equal in these regions (eight and nine, respectively) and both have one regionally responsible CAB, they vary greatly in size and structure. The former occupies an area that is over eight times as large and has less than half of the population of the latter. Table 2 displays the participants’ affiliations to the regions and the frequency of their involvement in the planning.

During the analysis, the recordings were replayed and transcriptions were analysed using the theoretical framework described above in order to extract issues interrelated with the sources of uncertainty. Thereby, the analysis emphasised both the decision-makers’ experiences with the NERP and their perceptions of the acquired knowledge. This analysis further sought to determine their desires for future modifications to the response-planning procedure. Observations made during analysis of the case-related documentation and interviews as well as those made personally in the field both enriched the subsequent discourse.

4. Sources of uncertainty in Swedish CIP management

This section presents the results of the study. Section 4.1 briefly describes the Swedish planning approach and establishes the sources of uncertainty with regard to NERP as MLP. Section 4.2 discusses insights from the interviews, and Section 4.3 synthesises these insights with the sources of uncertainty in NERP, as seen in Figure 3.

4.1. Multi-level planning for national power shortages

4.1.1. The Swedish planning approach

Swedish planning for the case of a power shortage, called STYREL, involves many actors at the national, regional and local levels and is structured as follows. Four national authorities initiate the planning via the Swedish Energy Agency (SEA), which proceeds in a top-down fashion to the individuals responsible
at all CABs. Simultaneously, all national agencies send information concerning infrastructures of national importance that are dependent on the power supply to each CAB where the particular infrastructures are physically located. Then, CABs respectively divide and forward this information, along with an associated call for action, to their municipalities. At that point, municipalities take inventory of their local infrastructure which provides elementary functionality to the local population. Following this inventory, decision-makers at municipalities attribute a priority class to each power consumer in accordance with a predetermined priority scale containing eight classes (MSB 2010, 10). Since the physical structure of a power grid still poses barriers to individually controlling each node, technical feasibility requires an aggregation of the categorised power consumers to controllable power lines. This aggregation is accomplished through collaboration between municipalities and the local grid providers by employing a prepared spreadsheet file. The data processing must be handled with care and adhere to information security guidelines (MSB 2010, 11–12; SEA 2014, 18–20). As a result of the local categorising process, a list is returned to the CABs respectively. Individuals responsible at each CAB aggregate these lists, which they receive from the municipalities within their regions. Power lines which cross county borders are categorised in co-operation with neighbouring CABs. Lastly, the obtained list is divided and forwarded to responsible providers of power lines, acting nationally, regionally and locally. All grid providers are legally obligated to use their lists during the following contingency planning (SEA 2014).

4.1.2. Sources of uncertainty in multi-level planning

The document analysis regarding the STYREL case reveals a complex system containing many actors and interrelationships. While the national government is responsible for strategic long-term planning, the SEA appears to be tasked with tactical planning. The operational planning is not specified, and the interviews indicated that individuals responsible at CABs and municipalities act upon local agreements. Nevertheless, it remains unclear how the budget and resources are allocated to the planning stages. Consideration of goals and means could provide conceivable clarifications. The different goals are enmeshed in one report, where the tactical long-term goal is to ‘alleviate consequences for society that emerge when manual load shedding must be executed’ (SEA 2014, 7) and the goal of the execution process is to ‘produce a plan that power-grid providers can use as basis for their response planning’ (SEA 2014, 25). To accomplish this, the identification and prioritisation of critical infrastructure must be a sub-goal of activities during the execution. This application of vague goals results in equally ambiguous means and guides for planners and decision-makers. The absence of measurements for an objective evaluation of the MLP approach amplifies the overall uncertainty through a lack of knowledge and poor controllability. Furthermore, the documents do not specify which events must occur to render the planning relevant. This may explain the apparent difficulty of clearly stating goals and providing appropriate means. Furthermore, the data reveal that the majority of decisions during the execution process at a municipality or CAB are made solely by one person who is respectively responsible. This raises high demands for both the decision aid that is provided and the characteristics of a decision-maker who is charged with the planning. Additionally, decision-makers may encounter various planning activities during their everyday work, which requires proper tactical and operational planning prior to execution of NERP. The current planning approach lacks co-ordination of similar planning activities. Reuse and planning of the local process is delegated to people who are locally responsible, who experience this as an inappropriate burden that necessitates much individual engagement and dedication of local resources.

Figure 2 summarises the deliberations and indicates sources of uncertainty (S) according to the MLP of NERP. It also marks the scope of the STYREL planning. As illustrated, the Swedish approach is incomplete because the plan’s further use in subsequent planning is not part of the STYREL approach. Therefore, this subsequent planning is not examined, and the national strategic planning is not a relevant source of uncertainty in this study. Instead, the tactical and operational planning are aggregated in S1, the complex planning process, which represents the planning’s reference process and its local instantiation. The execution falls within S2, the decision-making process, which concerns the ranking of critical power consumers and their antecedent identification. The hierarchy of elements indicates the decomposition/aggregation and co-ordination of goals, means, responsibilities, resources and process
4.2. Insights of decision-makers involved in planning

4.2.1. Response planning process

Most of the participants experienced the overall process representation as clear and understandable. In contrast, with respect to the execution, the decision-makers reported problems with the activities’ abstraction level, the information as a process object and the allocated resources. This implies that this reference process does not provide sufficient knowledge to appropriately instantiate the local execution. The result is a varied spectrum of local approaches, which yields different amounts of data to obtain and process in accordance with the local resources and individual engagement.

With three exceptions, the decision-makers all considered external resources to be necessary to obtain better results. However, nearly all participants requested specification of both the effort that was expected and the amount of data to collect. This absence of measurement specifications renders any evaluation of the proceeding impossible. Paired with no available feedback, the participants cannot rely on their results as input for further contingency planning. This was, however, the goal for many decision-makers, which diverges considerably from the communicated goal.

With one exception, the respondents viewed the four-year interval between planning iterations as appropriate, as there were usually limited resources or only minor changes in the local society. Moreover, results from the first planning iteration were used everywhere as input for the second iteration. Although...
this distinctly reduces the effort, it may not improve the reliability. The combination of weak input data
with new personnel, who have no experience with the first iteration or the method of data collection,
calls into question whether the approach is suitable for supporting the strategic long-term goal. The
participants further stated that they maintain regional groups to discuss related issues. Apart from a few
of these group meetings per year, no other knowledge management has been established. Therefore,
knowledge of the local process instance disappears over time and after staff changes.

Although many of the decision-makers found the technical support via spreadsheet files to be accept-
able, they also raised issues regarding its clarity, compatibility and functionality. The effort to develop
more suitable technical support may also relate to the appropriateness for strategic governmental
goals. Accordingly, the participants were concerned about information security issues. The processed
information and its owner are not clearly classified through the process steps and the progression to
the next step. These issues are instead dependent on the aforementioned local agreement.

4.2.2. Identifying and prioritising elements of critical infrastructure

The planning execution process contains two main objectives: first, the identification of power consum-
ners who maintain critical infrastructure, and second, a specific order of precedence of these consumers.
Whereas the quality of the first relies on the information that has been obtained, the second depends
on the decision-makers’ characteristics and the aid that is available for making the decision.

Participants with local experience from the first planning iteration reported that the information
collection during the first inventory was problematic and time-consuming. Much effort had to be
invested in discussions with internal and external stakeholders, which did not always result in stable
collaborations. This incomplete information hampered its effective processing, particularly due to local
time and resource constraints. Although some of the decision-makers noted that they were present
and inspected different objects, the majority performed the inventory from the office. This implies that
decision-makers had to rely on information that other departments delivered and that they obtained
during the limited time at their disposal. This resulted in almost no involvement of private or non-gov-
ernmental actors.

This collected information constitutes the input for the subsequent decision-making as well as for
future planning iterations. The responsible person individually makes nearly all decisions; only one
participant stated that a local group would decide based on consensus, and few maintained informal
discussions beforehand. A third of the decision-makers working individually stated that they received
assistance, at least the first time, from a trusted person in their local network. The majority of participants
found the classification of each consumer to be particularly difficult. This classification required a weight-
ing of an individual consumer’s importance to the local society. They appraised the aforementioned
eight-class scale as hard to apply. Moreover, to complete the ranking locally first and then regionally,
the spreadsheet files currently in use execute a cumulative calculation, which many decision-mak-
ers deemed inadequate and highly questionable. They experienced the lack of knowledge about the
quality and usability of their results as a challenge. This constellation may highlight the significance of
appropriate decision support, e.g. guidelines, assisting external experts and a reliable decision support
system that features evaluation possibilities for achieving national objectives.

4.2.3. Direction and guidance

In the distributed environment of the planning approach in question, decision-makers reported having
to perform with little to no job-specific leadership. They also noted an absence of appreciation from
their respective management. This was attributed to small organisations, where many of the participants
work alone in this planning or even hold multiple positions. Some of the decision-makers reported feel-
ing inappropriate when considering the effort or the plan’s usability. A lack of information from other
agencies and minimal interest from local stakeholders diminished their motivation and engagement.

The absence of feedback appears to be a systemic risk factor which can lead to conflicts between
actors, among other consequences. The respondents stated that they did not experience any conflicts;
this perception can indicate that no conflict management had thus far been necessary. Nevertheless,
some of the respondents reported that discussions within group meetings afterwards were concerned with the manner of classification and number of consumers in the ranking and conveyed regret over the lack of national dialogue about such issues. Furthermore, from a national dialogue, the decision-makers request a clearer motivation of the planning, including a clear communication of goals. They particularly wanted to know which efforts would be expected of them and which consequences could result from the plan for the local and regional requirements. According to the decision-makers, affirmative replies and a constructive dialogue can strengthen their sense of belonging and reassure them that they are engaging in worthwhile planning for the society.

Although the **STYREL** handbook provides overall insight into the process, it lacks information about the concrete regional and local proceedings. As mentioned, CABs and their corresponding municipalities have agreed upon this proceeding regionally. Within municipalities, local restrictions require further adaption, either to external consulting or internal staffing. Although this top-down approach was slightly questioned, nearly all respondents experienced hierarchical structures as flat and appreciated co-operation between municipalities and CAB and with SEA. Nevertheless, respondents felt powerless against the perceived insufficient commitment of national actors.

The majority of interviewees appreciated the available training opportunities, although they wanted to see more repetition and interactive training. In citing possible topics for training, they particularly

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### Table 3. Parameters specify sources of uncertainty.

<table>
<thead>
<tr>
<th>(S)</th>
<th>Process structure</th>
<th>Process object</th>
<th>Process goal</th>
<th>Time-horizon</th>
<th>Resource allocation</th>
<th>IT-support</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>+</td>
<td>○</td>
<td>○</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Information procurement</td>
<td>Staffing</td>
<td>Time frame</td>
<td>Location</td>
<td>Constraints</td>
<td>Decision aid</td>
</tr>
<tr>
<td>S2</td>
<td>–</td>
<td>○</td>
<td>○</td>
<td>+</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Leadership</td>
<td>Power hierarchy</td>
<td>Conflict management</td>
<td>Target goal communication</td>
<td>Training</td>
<td>Collective learning</td>
</tr>
<tr>
<td>S3</td>
<td>–</td>
<td>○</td>
<td>+</td>
<td>○</td>
<td>○</td>
<td>–</td>
</tr>
</tbody>
</table>

**Notes:**
++ excellent; + sufficient; ○ just acceptable; – insufficient; – – unacceptable.

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### Figure 3. Sources of uncertainty in complex planning and decision processes interrelate with several influencing factors.
mentioned knowledge regarding possible events and consequences – to understand cause-and-effect chains – as well as knowledge about the classification of infrastructure. Respondents with experience from local incidents believed that sharing local cases and explaining how they were handled could be a valuable contribution to collective learning. Such learning seems appropriate given that some respondents found a power shortage situation difficult to conceive. Besides regional group meetings, none of the respondents indicated another kind of knowledge management or transfer. Many identified this as an area for improvement, especially those who were recently hired.

4.3. Synthesis

The reports from the decision-makers refined the parameters of the theoretical framework that was employed during data collection. Table 3 presents the classification of the findings and their affiliation to the identified sources of uncertainty.

The results indicate that some of the applied parameters not only influence one source of uncertainty but also provide more complex interrelations. In particular, the characteristics of an individual decision-maker emerged as a relevant factor that influences uncertainties due to a lack of knowledge. The planning environment was identified as another factor provided by non-task-specific aspects, e.g. communication practices, local habits and conflicting situations, which can impact a decision-maker’s performance and the sources of uncertainty. In view of this, associated governance efforts need to address the sources of uncertainty due to a lack of knowledge, the characteristics of a decision-maker and the surrounding work environment. Figure 3 illustrates these interrelations.

5. Discussion

The first step of decomposing the Swedish STYREL case into hierarchical planning levels co-ordinated a closer investigation and revealed sources of uncertainty associated with the guidance, preparation and execution of this complex planning. Thereby, the complexity, ambiguity and uncertainty involved in such NERP for CIP became approachable. The decomposition of this and similar cases encourages a constructive dialogue regarding the involved interests, which in turn facilitates an alignment of goals and means towards a shared understanding among those who are concerned. Although the Swedish procedure aims to apply a shared and participative approach for consensus-finding, the study reveals a lack of guidance in co-ordinating the large number of actors in this distributed environment (Schwarz 2016, 168). Similarly, not all affected stakeholders are included in the process, e.g. the private sector is not meaningfully involved and the civic society is practically unrepresented. Discussing the various objectives that are involved would not only facilitate national process development but also support international collaboration and scholarly debate regarding sources of uncertainty that stem from a lack of knowledge (Bryson, Berry, and Yang 2010). Decomposing complex planning into hierarchical levels discloses discrepancies with respect to semantics, the scope of responsibilities and the benefits. A visualisation additionally fosters a dialogue about such interrelations and the significance of sources of uncertainty. Research considering other national and international planning for CIP cases could build upon the framework that has been provided.

The second step of decomposing the Swedish STYREL case characterised the sources of uncertainty from the first step in greater detail. Analysing relevant parameters within this or a similar MLP can indicate areas for improvement; the present study acknowledges decision aid and collective learning as the most urgent areas in the Swedish context (Table 3). As Figure 3 demonstrates, these parameters specify the sources of uncertainty, and they interrelate with characteristics of the decision-maker persona and non-task-specific factors, e.g. communication and collaboration within and among agencies and organisations. Thus, governance efforts should consider these interrelationships for appropriately addressing sources of uncertainty and their parameters. For example, in the Swedish case, planners perceive the information demand as high and feel compelled to create separate problem-solving approaches to reduce uncertainty. This necessity to develop individual strategies poses a challenge for planners at
Swedish municipalities and CABs. Therefore, the aforementioned analysis of the parameters facilitates a goal-oriented development for reducing such demands on individuals in several ways. First, government and agencies can encourage an aligned interaction in such a distributed MLP by clearly communicating national goals to the management of regional and local administrations (Alexander 2015). Second, improvements to decision aid, external assistance in the local process and training opportunities that facilitate collective learning can support responsible decision-makers in sharing knowledge and experiences (Lackner 2012). Third, appropriate openness in effective communication, proper documentation and the provision of feedback can further reduce goal conflicts and ambiguity within such complex planning environments (Werther 2013, 81–82). However, the number of participants limited the scope of this study. Further research could explore demands of the private and civic sectors in this MLP, e.g. involving power-grid providers, emergency services or non-governmental organisations. Thereby, a compendium of relevant parameters can be developed that specify sources of uncertainty in complex planning. This may co-ordinate further efforts in the development of cross-boundary planning for protecting societal values, the investigation of similar processes in other circumstances and the reduction of the ambiguity of related concepts.

6. Conclusion

Uncertainty pervades emergency response planning for CIP that portends a substantial impact on modern society. In view of the severe potential effects of an emergency such as a power shortage (Rinaldi, Peerenboom, and Kelly 2001), decomposing such NERP for CIP can reveal sources of uncertainty that stem from a lack of knowledge and can facilitate a deeper analysis of specific parameters. In Sweden, NERP involves many actors from the public and private sectors via MLP. Decision-makers at various hierarchical levels have to cope with uncertainty associated with both the construction of the future plan and the intensive processing of information about consequences for anyone who is affected. A decomposition of this situation enables a closer analysis that maintains a holistic perspective of NERP, which can ultimately help align goals and means towards advanced planning for CIP.

To address the sources of uncertainty in NERP for CIP, the study has examined the Swedish STYREL case, which is intended to protect society from the negative consequences of power shortages. In addition to a comprehensive document analysis, interviews were conducted with decision-makers from local and regional levels; parameters associated with uncertainty in planning and decision-making governed this investigation. Section 4 of this study has revealed three sources of uncertainty (S) related to this MLP: (S1) the planning (reference-) process in general, (S2) the decision-making process in particular and (S3) the direction and guidance alongside these processes. Six parameters specify each source of uncertainty with respect to a lack of knowledge.

In the Swedish case, one significant parameter that is associated with S1 is the sourcing of information, technical support and staff to achieve the goal of the national planning process. S2 includes the processing of information by helpful decision aid as crucial parameter and S3 comprises the target communication of goals and collective learning as substantial. Although all these parameters are relevant in the STYREL case, the present study acknowledges decision aid and collective learning as the most urgent areas for improvement. Since S3 further complicates the integration of the STYREL case into the NERP context, S2 combined with S3 thus emerge as most present in the Swedish context. Thereby, the study contributes to NERP advancement as follows.

First, the results provide a basis for further goal-oriented development of the NERP for CIP in Sweden and similar contexts. When addressing the presented sources of uncertainty, belonging parameters and influencing factors can help tackle and reduce risks interrelated with such planning situations. This thinking framework can be suggested as a foundation for advanced systemic thinking in NERP to facilitate an alignment of goals and means through complex planning environments, even in cross-border response planning. Second, the analysis framework that this study has refined can encourage further elaboration in other NERP contexts, which could then result in a range of parameters that influence sources of uncertainty. Moreover, since the study could not include all the views of affected stakeholders,
further research can address other interests that are involved. Since the Swedish case applies a unique perspective of NERP for CIP, a comparison with similar cases in other countries could be particularly interesting, though these are still absent in the literature. Lastly, insights from this study support an evidence-based communication of uncertainty and risks to actors involved in NERP for CIP and to the wider public. Thereby, a shared understanding of strategic public management for CIP involving national goals and feasible means can advise adequate planning and collaboration among actors to appropriately handle consequences for affected stakeholders.

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ORCID
Christine Große http://orcid.org/0000-0003-4869-5094

References


