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Assessing the capabilites to manage risks in energy systems–analytical perspectives and frameworks with a starting point in Swedish experiences

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ABSTRACT

In this study we conceptualise how a capability approach could be used for analysing the conditions for preserving security of energy supply. We derive a concept, 'energy system capability', to describe how well the system is designed for this purpose. Based on a socio-technical systems perspective, we suggest that this capability is composed of five categories of 'building blocks': technical structures, natural resources, economic resources, institutions and actors. The configurations of these building blocks and the interactions between them provide the system with a certain level of reliability, robustness, flexibility, adaptivity and capacity for swift recovery and handling. These building blocks and system characteristics form various capabilities along the event chain (prevent, withstand, recover, handle, prepare, detect etc.) that together build the energy system capability.

1. Introduction

Modern society is exposed to a variety of threats that, if they materialise, could have a negative impact on human health, the functioning of society and other core values. Preventing crises and severe disturbances and helping recovery from and management of these if they occur are central tasks for national and local governments. In fulfilling these tasks, firms and civil organisations, but also potentially households, will play important roles.

Most functions in society are dependent on energy. A well-functioning energy system that can withstand greater or smaller disturbances is therefore a central policy goal in most countries. Security of supply or energy security are often used to cover these issues in the energy literature. Security of supply could be interpreted in various ways, see e.g. Refs. [1–4]. In short it could be understood as uninterrupted supply of energy at a reasonable cost.

The energy system is complex and threats to security of supply can have a number of primary causes, such as technical or handling errors, weather or antagonistic events, imbalance between supply and demand, and lack of physical energy resources. These causes can in turn be results of lack of investments, poorly functioning markets, inadequate regulation, unstable political conditions in producer countries and unsuccessful development of alternative energy resources [1].

All in all, there is a broad variety of challenges to handle in order to preserve a high level of security of supply. In addition, there are other energy policy goals such as sustainability, including the need for deep cuts in CO_2 emissions, and economic efficiency that sometimes (but not always) are in conflict with security of supply. Important challenges to the energy systems' capability to provide security of supply are for example the transition to a low carbon energy system with e.g. more variable electricity production (and less interest to invest in retracting systems), the increased automation and the development of smart grids, reduced redundancies in the energy system for efficiency reasons, and increased geopolitical tensions.

Energy security has been a low priority issue in Swedish policy during the last two decades as a result of a relatively low dependence on importation of fossil fuels (with the exception for petroleum for transport) and the existence of a reliable electricity system, dominated by hydro and nuclear power. However, for the

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future, the challenges presented in the previous paragraph will be highly relevant in the Swedish context as well. For example, a future climate-policy induced transition in the transportation sector (currently totally dominated by fossil fuels) will provide major infrastructural and institutional challenges for the Swedish system.

Security of energy supply is affected by work in several policy venues (for the venue concept, see e.g. Ref. [5]). In the EU, energy policy (under Directorate General (DG) energy), policy making around critical infrastructures (the responsibility of DG Migration and Home Affairs) and the civil protection mechanism (the responsibility of the DG Humanitarian Aid and Civil Protection) are all of importance.

In several countries, e.g. Sweden, the UK and the Netherlands, capability assessments are used together with risk and vulnerability analyses in evaluating the preparedness of actors and systems to manage various threats [6]. On overall EU level too, a process for capability assessments has been developed under the civil protection mechanism [7,8]. For example, in 2010 the Commission provided risk assessments and mapping guidelines for disaster management [9] and has presented guidelines on risk management capability [10]. The use of capability assessments is still under development, however, and their exact role in risk and crisis management systems remains to be defined.

In Sweden, local and regional governments and national government agencies (including the Swedish Energy Agency) are required to conduct capability analyses and assessments. The purpose of these assessments is twofold. First, they are expected to provide central government with an overall picture of the general level of preparedness and in what fields there is the greatest need for further activities. Second, the evaluation process is in itself expected to encourage learning within the reporting organisations and, as result of that, lead to improved crisis preparedness. What the actors should report are described by regulation from the Swedish Civil Contingencies Agency (MSB), see Table 1. Similar types of reporting are presented in the EU guidelines. In general, the reporting are largely focusing on organisational issues and factors related to actors rather than system characteristics.

The current Swedish model for capability assessments has received criticism from both civil servants and the research community. Some believe that too much effort has been put into quantitative measurements rather than qualitative understanding, that it is not possible to carry out a thorough assessment and that it would be more realistic to develop a qualitative description and identify current limitations [12]. Others have noted that various actors are uncertain of how to interpret the concept of capability, a fact that restricts the opportunities to make an overall assessment [13].

The work, presented in this article, has started with the intention to present an approach that, better than current models for capability assessments, can take into account the specificities of complex infrastructure systems, such as energy systems. More specifically, the intention is to develop a concept that better takes into account the importance of system structures and physical artefacts than the current more actor directed approach used taken by the Swedish authorities. This approach takes its starting point in a perspective that sees energy systems as large socio-technical systems, which means that we see the system as consisting of technologies, institutions and actors and the interactions between these. The development of the approach has taken the deficiencies in the current Swedish system as a starting point. In this paper we present and discuss these approaches and propose a complementary concept, *energy system capability*, that we believe would be useful when studying a complex system such as the energy system.

2. Existing perspectives on capabilities

Capability has been used by organisations and researchers with a variety of meanings within risk management and crisis preparedness. For example, in EU decision 1313/2013/EU, regarding a civil protection mechanism, risk management capability is defined as "the ability of a Member State or its regions to reduce, adapt to or mitigate risks (impacts and likelihood of a disaster), identified in its risk assessments to levels that are acceptable in that Member States". In Sweden, the agency responsible for this has proposed a definition saying that capability is how well one or more organisations, activity or society as a whole: i) manages to prevent an extraordinary event from occurring or, ii) if an extraordinary event occurs, is able to carry out the tasks prioritised among their normal activities and manage to handle the event in itself [14]. Overall capability is defined as a number of capabilities along the event chain and includes e.g. capability to prevent, prepare, withstand, recover and handle.

Lindbom et al. [15] review a number of definitions of the concept of capability and identify five trends regarding the definition of capability: i) capability is equated with resources; ii) resources constitute an important component of capability; iii) capability describes the ability to do something; iv) capability is a capacity; and v) capability is a factor affecting an outcome and a goal. Palmqvist and Eriksson [6] also note that capability, ability and capacity are often used interchangeably, even if capacity is often related to a potential level of performance that can be reached using the capabilities.

Lindbom et al. [15] stress that capability has to be connected to a specific task, i.e. a capability to do something and an agent (an organisation, a person, a technical system). Although it can be debated whether a technical system really can be an agent, in the following we argue that capability can be attributed to more abstract subjects such as an infrastructure or a socio-technical system.

Table 1
Various areas for describing and evaluating capability assessments.

Fields to be covered is the assessments of risk management capabilities assessments in EU member states [10]	Fields that according to Swedish regulation should be covered when reporting the crisis preparedness in Swedish municipalities [11]
Comprehensive Analytical Framework	Risk management procedures for risk and vulnerability analysis
Coordination	Plans and routines
Expertise	Cooperation among actors
Involvement of other stakeholders	Communication (ICT-security)
Information and communication	Education
Method	Exercise
Equipment	Personal and material resoruces
Financing of implementation	
Strategies/policies/methodology	
Procedures	
Infrastructure	
Equipment and supplies	