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Learning from adverse events in the nuclear power industry: Organizational learning, policy making and normalization

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ABSTRACT

Nuclear power accidents repeatedly reveal that the industry has an incomplete understanding of the complex risks involved in its operation. Through analyzing the investigation of a nuclear power incident in Sweden in 2006, I show how the industry's learning practices shape recurrent normalization of risk regulation after such surprises. Learning is shaped through institutionalized measures of sufficiency and particular "risk objects" (e.g. human factors and safety culture) created through learning from previous events. Subsequent regulatory measures are shaped through improvement scripts associated with these risk objects. These learning practices exclude alternative conceptual perspectives to understand and address safety-critical incidents. Latent risks will therefore produce similar events in the future. The article contributes to the literature on organizational learning, policy making, sensemaking and normalization in complex systems. To improve learning from incidents and regulation in high-hazard industries, social scientists and a wider circle of stakeholders should be included in the regulatory and post-incident examination processes.

1. Introduction: policy logics, organizational learning and normalization

In contrast to nuclear waste management, nuclear power operation is most often de-politicized. Even if accidents such as those at Three Mile Island, Chernobyl and Fukushima at first challenged current risk analyses within the nuclear power industry, they are eventually normalized, whereby regulatory practices become "politics by other means".

This paper addresses what shapes such normalization through analyzing the industry's investigation of a Swedish nuclear power incident in July 25, 2006. The analysis shows that learning in the nuclear power industry is framed through institutionalized measures of sufficiency and particular "risk objects" (e.g. human factors and safety culture) created when learning from previous events. Subsequent regulatory measures are shaped through improvement scripts associated with these risk objects. These learning practices excluded conceptual perspectives to understand and address adverse events. Latent risks will therefore produce similar events in the future. Because of close similarities in nuclear power expert rationale and regulatory regimes between different countries and given the ongoing debate regarding complex technology systems and risks associated with nuclear energy, this paper adds to the discourse regarding the regulation of high-hazard industries. More specifically it adds specific recommendations regarding learning from and investigating high-hazard industries, catastrophic and near catastrophic events.

Reactor 1 at the Forsmark nuclear power plant was shut down and the emergency power supply (to cool residual heat) was half-blocked due to the interaction between a maintenance error (trigger) and the failure of three

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technical subsystems (latent design errors), according to the plant's report [1]. The maintenance error caused an outside switchyard to uncouple reactor 1 from the national grid; inadequately installed low frequency protections for the turbines caused a transient electrical surge through the plant; and two out of four emergency power systems failed due to faulty design.

Half of the instrument panels in the control room went black due to the loss of electric power. Moreover, instrumentation in the control room was misleading due to deficiencies in the human–machine interface, training and manuals. The operators did not know if the control rods had been fed into the reactor, or the reactor's water level or pressure. However, owing to their instructions, experience and training, they were able to deduce what had happened and after 22 minutes they manually connected the regional 70 kV grid to the plant. The water level decreased with two meters but the core was still covered. If more than two emergency power systems had failed, the operators' intervention would have been essential to save the core from damage.

The nuclear power industry world-wide was surprised by the effects of the surge on the emergency power system and concerned since many other plants shared design features with Forsmark [2]. Moreover, the different parts of the emergency power system were interdependent, violating prescribed design rules. However, about a year after the incident, the Forsmark case seemed to be closed, the problems fixed and public trust in nuclear power was restored [3].

The plant's report and documents from the regulator, Statens Kärnkraftinspektion SKI, the Swedish nuclear safety agency, show a very varied response to the event. The industry had not inquired into the causes behind the control room operators' successful work and it had inquired into some but not all of the failed installation and design processes. Even when investigating causes, answers and remedies were vague. The technical errors were fixed and for some processes procedures were changed or efforts were made to improve adherence to existing procedures while other processes were left unchanged. This response left many unaddressed questions: Why was the incident surprising to the industry but later closed? What informed learning and remedy measures from this incident? What consequences might it have? How can learning from incidents be improved in order to match the complexity of nuclear power risks?

To answer these questions I have used an ethnographic approach to identify and explain the rationales that guide industry experts learning efforts [4]. To this end, I have contrasted investigation reports with interview data, seminars and dialog with industry experts. The Forsmark incident was a valuable "window of opportunity" for the nuclear power industry to learn from both success and error. Simultaneously, the investigation is a frequent type of practice that provides an opportunity to analyze how learning practices within the industry are shaped. The incident story was spread worldwide and the regulator (SKI) arranged an international conference that provided ample learning opportunities. The incident investigation produced a wealth of data and it also aroused strong public and media interest since it raised questions of institutional trustworthiness on behalf of both the plant and SKI. For these reasons, the analysis contributes significantly to the understanding of policy learning, organizational learning in high-hazard industries and normalization of error as well as suggests how to improve regulatory practices.

The literature on organizational learning in high-hazard industries [5,6] focuses on how investigation teams' disciplinary frameworks shape their findings in terms of calculated logics, fixing orientation and the like. It is often found that organizations are not able to advance beyond single-loop learning. The normalization literature addresses the pre- or post-investigation processes. Data that in hindsight proved to signal impending danger is often normalized in advance of accidents because the relevant audience does not recognize its significance appropriately [6,8]. After an accident, normalization is often seen as attempts to cover up wrongdoings that hindsight reveals [9]. Moreover, the surprising nature of the Forsmark incident suggested that it could have become a "focusing event" that called for radically reconfiguring regulatory practices and structures [10–12]. Policy learning is often seen as triggered by such events and shaped by political dynamics favoring symbolic and speedy, but often misguided, measures [10].

This analysis indicates that there were both pre- and post-normalization caused by the same framing processes, and not by attempts to cover-up wrong-doings revealed in hindsight. These framing processes also prevented the incident from becoming a "focusing event" that could have led to double-loop learning and regulatory reform.

These findings suggest that the nuclear power industry's learning practices should be challenged and complemented through inviting social scientists and other stakeholders into learning from accidents to match the complex risks within nuclear power design and operation. This would provide critical questions and powerful conceptual tools necessary to identify and understand both successful processes (such as the control room work) and failed processes (the design processes).

2. Learning practices

This paper is based on concepts from situated learning theory, knowledge management, science, technology and society (STS) and the sociology of risk. When individuals participate in everyday practice in communities of practice their learning from accidents is shaped by organizational procedures, practices and beliefs as well as various technologies [13]. Ethnographic studies show that these features also shape learning in everyday control room work [14–16]. Moreover, organizations learn when individual knowledge is codified, synthetized and transformed into new technologies, training programs, policy, regulations, plans and organizational structure [17]. In the nuclear power industry, learning is shaped through *calculated logics*, by transforming *anomalies* and *uncertainties* into certain well-known *risk objects* created after previous events and associated with specific *improvement scripts,* as well as demands to transform "unruly technology" into *sufficient* and *decisive* reports.