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Smart grids, smart network companies

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ABSTRACT

The introduction of intelligent technology to turn electricity networks into smart grids is an important vehicle to meet the many challenges modern society poses. However, technology alone will not make energy supply more intelligent and may for the medium and long range even involve risks of intelligence reduction in the larger energy system. Crucially important, yet mostly overlooked is the intelligence of the service company that runs the grids. Based on concepts of knowledge management and learning organizations, the paper develops guiding principles for designing intelligent knowledge infrastructures within companies adopting smart grid technologies. The case study of intelligent SASensor technology, which is currently being introduced by the Dutch power network administrator Alliander, provides an illustration of the argument.

1. Introduction

The energy supply is expected to change drastically in the next few decades. The energy sector is facing at least five interrelated challenges. First, the network must be adapted to handle renewable energy sources and sustainable energy sources. The fluctuating and partly unpredictable capacity of such sources places specific requirements on both the network and the sector (Jacobsson and Bergek, 2004). Second, as these sources have partly decentralized generation, a transition to distributed generation is required. That is, instead of generating power from a small number of main centres and feeding it into the network, power is fed into the network from many distributed energy resources (DER; e.g. Hammons, 2008). For instance, more and more customers are generating their own power and supplying it to the network. The network therefore needs to be changed from a unidirectional transport facility into a two-way facility. Third, the demand for electrical power is continually increasing. This may lead to capacity problems, particularly during peak load hours, even for networks that currently have ample capacity. Fourth, and in part having the opposite effect of the third point, government policies, pressure from interest groups and CSR strategies from the electricity sector itself are aimed at making it possible to use energy more responsibly, that is, to use less energy. Therefore, networks and related services have to enable consumers, both households and companies, to gain detailed insight into their energy use, and should also contribute more generally to creating a new ‘energy culture’ in which savings are effected (Wallenborn et al., 2011). Fifth, it is important to explore ways to increase efficiency and ensure network reliability when looking for improvements in the energy sector.

As a result of these developments, electricity networks must be more intelligent and their capacity must be increased. In the near future, they must become active and adaptive networks with their own intelligence, that can evaluate their own performance and rectify errors (McDonald, 2008; Wade et al., 2010; Wang et al., 2011). For instance, they must become more efficiently structured and remotely controlled, and accountable measurements and monitoring are needed. The SmartGrid and GridWise initiatives in the EU and the USA, respectively (Coll-Mayor et al., 2007), are aimed at enabling the sector to zero in on these developments. The discussion of this theme in the literature is striking in that the desired and predicted transition to smart grids is approached primarily as a technological issue. However, such a transition is a comprehensive project, one that involves not only technical replacements but also a new way of working, training staff, developing and using the knowledge required, standardizing protocols and procedures, and ensuring that staff follow these protocols and procedures. Smarter networks do not automatically lead to smarter network companies (cf. Hendriks, 1999). As several authors argue and support empirically (e.g. Gill, 1995; Orlikowski, 1992; Robey et al., 2000), technology may have disabling effects on learning. A

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daily-life example concerns the use of navigation systems in cars; when people overly trust the adequacy of routing information provided by these devices and therefore switch off their own learning orientation, the technology may lead them astray. A well-known problem in the relationship between technology and learning is the so-called competency trap: the more successful a particular technology is, the stronger an organization may build up favourable experiences that may inhibit critical reflection of its limitations and detection of possibly superior alternatives (Levitt and March, 1988). Increasing the intelligence of the network may therefore even be at odds with the intelligence of the network company and thus in the long run threaten the intelligence of the network itself. One question that should be explicitly dealt with is whether the organizations, and through them, the entire energy system, will become less flexible as the networks become smarter. How attractive will it be to work for a network company if any creative challenge in such work is greatly restricted by a standardization with few theoretical challenges? What about the capacity to not only learn from errors in the functioning of the smart grid (single-loop learning, or learning by recognizing and solving problems on the basis of applicable assumptions and standards; see Argyris and Schön, 1978), but also to learn about the broader developments in the energy market that may lead to a changed insight into what is ‘smart’ about the smart grids (double-loop learning, or learning about the assumptions and standards used so as to label something as ‘wrong’)? The intelligence of electricity supply is found not only in the intelligence of the network, but also – and perhaps even more so – in that of the organizations that supply services for that network. They, too, must be sufficiently and adequately intelligent. Moving intelligence into technology should be combined with paying explicit attention to the intelligence and learning capacity of the network organization. Technological intelligence does not automatically and inevitably produce organizational intelligence. This relationship is twofold. Not only must the network organization be adapted to the technological possibilities and requirements of the intelligent network, but the learning ability of the organization must also be taken as a criterion for continued assessment of the possibilities and threats that come with technological developments. Given this crucial link between the intelligence of the network and that of the network organization, a suitable approach to identifying the organizational issues concerning the transition to smart grids can be found in the literature on intelligent organizations, organizational learning and knowledge management (e.g. Hislop, 2013). This field has a rich history in which many, often contradictory theoretical and practical approaches have been developed. The label ‘knowledge management’ will be used as an umbrella term to summarize the knowledge and learning perspective on organizations.

The argument developed above proposes that smart networks require intelligent organizations – i.e. these organizations should produce and apply the knowledge to run these smart networks and to learn with respect to them. We argue that knowledge management can help by enabling the production and application of this knowledge. The goal of the paper is to explain how KM can help to ensure that the required knowledge for realizing and adapting the smart networks is produced and applied. In other words, the question that is central in this paper is how the knowledge infrastructure of a network organization can be set up in light of the knowledge processes and practices at play in services that are related to smart grids. The contribution of this paper therefore lies in developing practice-oriented theory concerning organizational integration of smart grid technology. The main methods used to achieve this are a dedicated literature review and argumentation. Based on that literature review, a selection, interpretation and combination is made of elements in extant theories and insights, particularly from the domains of knowledge management, organization theory and smart grid technology. For illustration purposes, a case study on the organizational issues of the introduction of SASensor by the Dutch power network administrator Alliander will be discussed. SASensor comprises the hardware and the software that is intended to render intelligent the electricity network managed by Alliander. The following section will first describe the subject of knowledge management in light of the issues that are relevant for designing network companies that aim to integrate smart grid technology in a smart way. Next a general design rationale for drafting knowledge infrastructures for smart grid technologies will be developed. Possible specifications of the steps in the proposed approach will be illustrated by means of Alliander's SASensor case study. The paper ends with a discussion and a conclusion.

2. Knowledge management: from business processes to knowledge processes and practices

Knowledge management became a highly popular subject within the field of organization studies in the 1990s. Connections between knowledge – and the associated concept of learning – on the one hand and organizations and management on the other have a much longer history, one that dates at least as far back as the work by Von Hayek in the 1940s (Hayek, 1945). The label of knowledge management (KM) signals a relatively recent set of additions to these discussions. While KM originated in Europe during the 1970s and 1980s (Wiig, 1997), global academic interest in the subject did not arise until the early 1990s, when American and Japanese authors also embraced the concept (Hislop, 2010). Landmark publications commonly associated with the KM boom in the 1990s are *The Knowledge-creating Company* by Nonaka and Takeuchi (1995) and *Working Knowledge* by Davenport and Prusak (1998). Despite predictions that KM would be a passing fad sold by management consultants and ICT firms looking for new markets (e.g. Wilson, 2002), the development of the KM discipline has not followed the typical bell-shaped curve of fashion, but has managed to maintain a high level of attention in academic debates (Hislop, 2010).

2.1. Types of knowledge

KM's popularity rests on the fact that knowledge is credited with traits that make it outstandingly suited as the basis for defining competitiveness in today's world. Two aspects of knowledge have gained prominence in the arguments underlining the strategic importance of knowledge. The first is the distinction between explicit and tacit (or implicit) knowledge (e.g. Nonaka and Takeuchi, 1995). Explicit knowledge ‘can be expressed in formal and systematic language and shared in the form of data, scientific formulae, specifications, manuals and such like’ (Nonaka et al., 2000, p. 7), whereas tacit knowledge is ‘highly personal and hard to formalize. […] Tacit knowledge is deeply rooted in action, procedures, routines, commitment, ideals, values and emotions’ (Nonaka et al., 2000). “It `indwells' in a comprehensive cognisance of the human mind and body” (Nonaka et al., 2000). Now that turbulence rules markets and service firms are the main producers of wealth, knowledge appears as an increasingly important strategic resource for organizations. Because knowledge is essentially tacit, contextual and developed from experience, it is considered hard to appropriate and transfer, and is seen as inimitable and flexible, yet enduring (e.g. see Grant, 1996; Zack, 1999). Weggeman (1997) offers the formula $K = I \times ESA$ ($K =$ Knowledge, $I =$ Information, $E =$ Experience, $S =$ Skills and $A =$ Attitude) for capturing the combination of explicit and tacit sides of knowledge (information is taken to refer to the explicit sides while experience,