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Organizing synergies in integrated energy systems

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Abstract

Although it has been proven that systems for integrating energy flows of different businesses are technically possible, economically profitable and environmentally sound, few such systems have been realized in Norway. This paper shows that other aspects must be considered, and argues that such infrastructures should be understood as sociotechnical. We studied a regional cluster in Norway, Kviamarka, and how the businesses successfully integrated energy flows by integrating production processes in the energy system. The surplus heat, cooling water and CO_2 output that are byproducts of several companies in the cluster are used by other companies in the cluster, which makes it more energy-efficient. This case showed how integrating companies' energy flows involve a material and structural bridging of the companies and a focus on the mutual trust and interdependence of the actors in order to establish and maintain a collective energy system. Establishing a system for synergizing energy flows involved solving issues regarding negotiation of roles and responsibilities as well as context-specific issues. We also report on findings from the project INTERACT, in which we studied sociotechnical issues in synergizing energy flows through different situations and scenarios. To study context-specific issues in other initiatives for creating energy-efficient systems, we developed a scenario typology. The scenarios are defined not by the technical properties of the system but by how the actors are bound together by the energy infrastructure and how that affects their respective roles and responsibilities. The typology highlights different core challenges and possibilities related to different socio-technical systems. The rationale behind energy efficiency is based on the idea that different flows of energy (surplus heat, cold etc.) can be synergized by connecting different actors. Thus, the potential for innovation lies in how actors are organized and use their complementary energy resources.

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Keywords: Energy efficiency, integrated energy systems, synergies, organization, innovation processes

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1. Introduction

Integrating energy flows from businesses, households and buildings can be a cost-efficient method of optimizing existing energy resources. Surplus heat and cold from industrial processes can better be utilized in-house or transported to nearby buildings where the resource is needed. Although the technological issues involved in utilizing, transporting and storing surplus heat and cold have been widely researched from the engineering point of view, we found a knowledge gap regarding the inter-organizational issues that arise when different organizations or households connect, which is important for improving energy efficiency.

Improving industrial energy efficiency is viewed by the IEA [1] as the main contribution to reducing the output of greenhouse gases in developed countries. One method involves using surplus heat and waste energy from one industry by nearby companies or to heat buildings. The Norwegian Agency for Energy Efficiency [2,3] stated that there is a huge potential for using surplus heat from industry cost-effectively with existing technology. Although such solutions would make several industry clusters more sustainable as well as reduce energy costs, few clusters have integrated their energy flows [3,4]. By studying the phenomenon as a regional innovation process and a matter of organizing synergies, this paper illuminates this perceived paradox within the existing research on why the use of surplus heat between companies is not more common, when in many cases it is technically possible and economically rational.

In this article, we first demonstrate the fundamental differences between existing models of energy-efficient innovation processes and the actual realization of such a system. The case study shows how informal ties between individuals in the companies, municipality and local energy supplier were imperative to create an energy-efficient cluster with the additional benefit of making the entire region more sustainable.

Drawing on this case study, and results from the ongoing project INTERACT, the paper illuminates organizational challenges and regional frame conditions for establishing integrated energy systems.

1.1. Methodological and theoretical approach

In this article, we synthesize the results from the projects INTERACT (ongoing) and CREATIV [5] in which we conducted two case studies of integrated energy systems as well as engaged with industry partners in several initiatives for integrating energy flows across company borders. By using a holistic sociological approach for these issues, we highlight conceptual and context-specific issues that are not visible through a barrier-oriented method of explaining these issues.

First, we argue that energy systems must be understood as *sociotechnical systems* (see Hughes [6] and Monteiro [7] for a thorough explanation of the sociotechnical systems). Sociotechnical systems highlight how energy systems not only consist of technical properties (pipes, valves etc.), but must also be understood as a network of material artifacts, organizational properties, people involved, regional frame conditions and contextual factors. Thus, integrating energy flows between organizations involves more than technical tinkering. We must also consider associated technological, social and organizational challenges. Integrating energy systems implies a sociotechnical change, and we must study the contextual factors, regional frame conditions and organizational impact.

One way of discussing frame conditions for integrating an energy system is to study the social foundation in a region for collective innovation processes. Social capital has become popular in studies on the dynamics of knowledge-sharing and innovativeness in many disciplines. Our use of the concept builds on Coleman's [8] and Putnam's [9,10] theoretical frame; they described social capital as a "collective good" of which a country or region can have certain stock. Putnam [9:664-665] described social capital as "features of social life – networks, norms and trust – that enable participants to act together more effectively to pursue shared objectives." Based on our case of businesses connected to use surplus heat, we argue that a region's stock of social capital can be an important enabler for the area's ability to organize these synergies and enable regional innovation processes, but not necessarily in all scenarios.