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Implications of systems integration at the urban level: the case of Hammarby Sjöstad, Stockholm

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ABSTRACT

Systems integration is a trend in the quest for increased environmental performance in urban districts, yet its implications are not yet fully known. Hammarby Sjöstad is a district in Stockholm, Sweden, designed with high environmental ambitions. These ambitions were later expressed in the Hammarby Model, an integrated infrastructural system aiming to minimize the metabolic flows of the district by closing its material and energy flows. Various integrated systems were already present in Stockholm when discussions began around the development of the Hammarby Model. Using a conceptual framework inspired by transition theory, this paper analyses the process of designing and building the Hammarby Model. Our aim is to create a better understanding of the implications of systems integration at the urban district level. The findings of the study show that systems integration may both enable and constrain further innovation. On one hand, integration facilitates the implementation of technologies that are add-ons or that solve a reverse salient experienced by the integrated system. On the other hand, technologies that are perceived to threaten the integrated system are locked out, prohibiting further optimization of the system.

1. Introduction

In 2009, the urban population of the world surpassed its rural population, and it is expected to keep rising (DESA, 2009). Increasing environmental concerns, especially climate change, declining biodiversity and depletion of resources, are putting pressure on municipalities to come up with strategies and measures to offer a comfortable and healthy living environment while minimizing environmental degradation and preventing further contribution to climate change. As a response to these new demands, a number of sustainable urban developments have been initiated worldwide: for example, Växjö (Växjö Municipality, 2011), Almere (DuurzaamheidsLab Almere, 2010), Abu Dhabi (Masdar City, 2011) and Caofeidian (SWECO, 2011). All of these cities rely on strategies of systems integration, such as using domestic waste systems to generate energy, using sewage to produce transport fuel, treating grey water for use as secondary domestic water or for irrigation, using the sludge from wastewater treatment as fertilizer in agricultural areas, and so on.

Such integrated solutions represent efforts to close material and energy cycles to give urban areas the characteristics of ecosystems, which is congruent with viewing urban metabolism as a circular, rather than linear process. Herbert Girardet has been pleading for this approach to urban planning and development since 1992, when he argued that linear thinking had led to increasing consumption of natural resources and increasing disposal of waste in the environment (Girardet, 1992). Similarly, in 1998 Richard Rogers argued that we need to think about cities as circular systems rather than linear (Rogers and Gumuchdjian, 1998). Since then, a number of scholars have done research in the field of urban metabolism (Kennedy et al., 2007; Newman, 1999), and scholars in the field of industrial ecology have promoted the concept of systems integration as a means to increase environmental performance (Ayres et al., 1997; Korhonen, 2001; Tibbs and Little, 1992).

However, while a great deal of research argues in favour of 'systems integration', few in-depth analyses have been made to explain the process through which these integrated systems come about in practice and what might be their implications. Systems integration may increase the innovative capacity of the integrated system and thereby contribute to a continuing improvement of the new system. Alternatively, it may in fact create barriers to future fundamental change, prohibiting the implementation of radical

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innovations needed to improve the environmental performance of the system as a whole.

This paper aims to create a better understanding of the implications of systems integration at the urban district level, using the Hammarby Model as a case study. The Hammarby Model is based on the integration of infrastructural systems in Hammarby Sjöstad, an almost-completed sustainable district of Stockholm, Sweden. We chose this case study for several reasons. *First*, Stockholm has a strong environmental policy; for its decades of innovative environmental policies, it was the first European city awarded the title of European Green Capital of Europe in 2010. *Second*, systems integration, as a strategy to achieve environmental goals, has been part of the long-term environmental strategy of the city for over 20 years (Stockholm Municipality, 1989, 1996b, 2003). This case study provides the opportunity to study the influence of existing integrated systems in new urban developments. *Third*, the development of the Hammarby Model, started in the mid-1990s, is now complete; we therefore have the opportunity to analyse the entire formative process of the new integrated system. *Fourth*, Hammarby Sjöstad has inspired a number of other developments worldwide (Boverket, 2008), so our findings here may be broadly applicable.

Section 2 of this paper describes systems integration and different systems innovation theories. Section 3 describes the conceptual framework, methodology and system boundaries of the paper. In Section 4, the Hammarby Model and its process of development is explained and in Section 5, the inclusion and exclusion of technological innovations is related to the theoretical background. Section 6 discusses the findings, draws conclusions and points to the need for further research.

2. Systems integration and system innovation theory

The aim of systems integration is to optimize existing sociotechnical systems of consumption and production by connecting them to create synergies and reuse waste (Ayres and Ayres, 2002). When systems, initially working independently from each other, become connected, organizations and technologies within them have to start interacting with one another. We understand each separate sociotechnical system as consisting of artefacts, knowledge, labour, capital, and cultural meaning, which in interaction fulfil a given societal function, such as electricity production, wastewater treatment, waste management, etc. (Geels, 2004; Hughes, 1987). Hughes, in his pioneering work, describes sociotechnical systems as both shaped by and shaping their environment (Hughes, 1983). This suggests that social and technical elements co-evolve, and that change in one can only be understood if one considers the change in the other.

There are various ways to study sociotechnical change. Scholars using a *Hughesian perspective* (large technical system approach) often use concepts such as *reverse salient* and *critical problem* (Davies, 1996; Hausman, 2010; Van Der Vleuten and Kaijser, 2006). During its growth, a sociotechnical system may encounter a reverse salient in which components in the systems develop slower than the rest of the system and may compromise system growth. When a reverse salient is recognized by relevant stakeholders and translated into a critical problem, the problem can be solved and the system will continue to grow. However, the definition of what a reverse salient is might differ though among actors. Furthermore, a reverse salient may be present even when actors in a system do not recognize it as such (Moors, 2006).

Another way to study sociotechnical change is to use *the multi-level perspective (MLP)* developed by scholars interested in understanding systems innovation (Elzen et al., 2004; Geels, 2002, 2004). That is when the entire structure of how things are done changes, or as Geels explains it: 'System innovations are not merely about changes in technical products, but also about policy, user practices, infrastructure, industry structures and symbolic meaning, etc.' (Geels, 2006). In the multi-level perspective, systems innovations are understood to result from the combined interaction between processes taking place at three levels: *micro*, *meso*, and *macro*. Following Geels, the meso level corresponds to the sociotechnical regime (Geels, 2005), understood here as the existing sociotechnical system. Subsequently, the regimes are prone to lock-in situations and path dependency. The micro level corresponds to the level of niches, protected spaces where technological innovations can be developed and tested (Kemp et al., 1998). Finally, the *macro* level represents the sociotechnical landscape, including the broader external factors, such as fuel prices and cultural beliefs that can influence both the niche and the regime (Geels, 2004). This level usually changes rather slowly, though sudden changes (e.g. credit crisis) can also occur (Tukker, 2005).

The MLP perspective has been used to analyse broad sociotechnical transitions (Geels, 2002; Nykvist and Whitmarsh, 2008; Verbong and Geels, 2007), and a few studies already describe how different regimes interact with one another and the kinds of challenges that may result from these interactions (Konrad and Truffer, 2008; Raven and Verbong, 2009). However, no research has yet been done to understand how these levels shape innovative processes when systems are integrated. Furthermore, the scholars who developed the MLP also suggested a triangular analytical model to conceptualize the co-evolution between technical and social elements. Geels identifies three key analytical dimensions: the sociotechnical system (sociotechnical configuration); the human actors (organizations and social groups); and the rules (institutions) and six types of interactions between these dimensions (Fig. 1) (Geels, 2004). In brief, Geels states that the three analytical dimensions cannot act by them selves, without being influenced and/or influencing the other dimensions. Applied to systems integration, Geels's triangular analytical framework (Fig. 1) suggests that the integration will be shaped by the sociotechnical systems themselves, as influenced by actors, their organizations, and social groups in relation to overarching rules and institutions.

Subsequently, the integration process can create changes in any of the three dimensions (Fig. 1), which will in turn cause changes in the other dimensions. Geels's framework can also be used to identify challenges that systems integration may face. *First*, existing sociotechnical configurations may constrain the integration

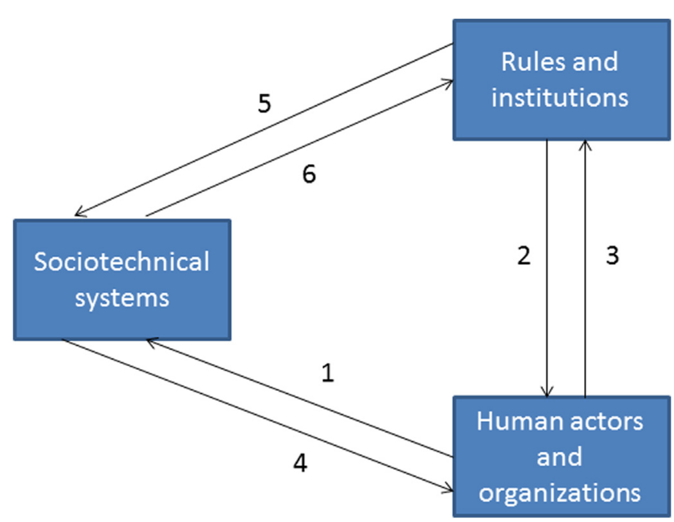

Fig. 1. Geels's triangular analytical model (Geels, 2004).