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Innovation capabilities and challenges for energy smart development in medium sized European cities

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Abstract

Transition towards becoming Energy smart city integrating different areas of energy production, distribution and use in a community requires a spectrum of capabilities. The paper reports on findings from the EU planning project PLEEC, involving six medium sized European cities. The purpose of the paper is to describe innovation capabilities and challenges in the complex, systemic innovation journey of cities in the transition to sustainability. A case of implementing an innovative project for electrical vehicles in Eskilstuna is presented illustrating both technological potentials and innovation challenges.

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Keywords: innovation; systemic innovation; Low carbon city; urban energy system; Renewable energy; electrical vehicles.

1. Introduction

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More than 50% of all people globally are living in cities today [1]. Enhancing sustainability and efficiency of city energy systems is thus of high priority for global sustainable development. Energy solutions and their efficiency improvement is dependent on action from in principle all people and organizations, but in development of energy system efficiency collective action of different kinds is often needed. We are focusing on medium sized cities which are collective action bodies for sustainable energy planning which have considerable potentials in this respect.

2. The EU project Planning for Energy Efficient Cities

The PLEEC project – "Planning for Energy Efficient Cities" – funded by the EU Seventh Framework Programme uses an integrative approach to achieve sustainable, energy–efficient, smart cities. By coordinating strategies and combining best practices, PLEEC will develop a general model for energy efficiency and sustainable city planning**.** The main strategies covered by PLEEC are technology, structure and behavior. Some of the objectives of the project are:

- To assess the energy-saving solutions and potentials for a comprehensive city planning
- To demonstrate how integrative planning is more efficient than separate measures
- To develop a synergized model for energy efficiency planning considering city key aspects
- To create action plans to be presented to decision-makers in the cities
- To identify the future research agenda on the issue of energy-smart cities.

The partner consortium consists of 18 partners from 13 different European countries representing six mid-sized cities (Eskilstuna, Tartu, Turku, Jyväskylä, Santiago de Compostela and Stoke-on-Trent), nine universities (Mälardalen University, Turku University of Applied Sciences, Hamburg University of Applied Sciences, Vienna University of Technology, University of Copenhagen, Delft University of Technology, University of Rousse, Santiago de Compostela University and University of Ljubljana) and three industry partners (Siemens, Smartta, Eskilstuna Energy and Environment).

In the PLEEC project we have covered different aspects of energy efficiency improvement actions like technological, structural and behavioral aspects. These have then been integrated into action plans for the participating cities, but will also be utilized by any city. In this paper we will cover primarily the technological aspects, but also touch the other, and focus on the issue of innovating more sustainable technologies.

This is not the only initiative on energy efficient or smart cities. It is one of few within the EU FP7 programs. Another initiative is by smart cities council where guidelines has been presented for city mayors, city managers and their staff. This shall help cities with vendor-neutral information. They also have ranked different cities with respect to different factors as good examples.

3. Innovation capabilities and challenges

Sustainable development towards energy smart cities are quite complex sociotechnical processes where technological and market systems, and social factors like stakeholder networks and coalitions, culture and economic factors, interact. A sociotechnical perspective is needed addressing changes on concrete sectorial or systems level, focusing on the dynamic interactions and co-evolution between technology, market and behavioral change. In PLEEC this is covered by the parallel focus on technological, structural and behavioral perspectives. The systems of technological and social factors need to be recognized as dynamically evolving innovation systems, involving multiple actors and groups as drivers in technological, market, institutional and social domains [2, 3, 4, 5, 6] where the appropriate analytical and planning level is communities or organizational fields [7]. Embarking on the road towards sustainability is a formidable societal challenge, requiring complex, systemic innovation journeys involving not only new knowledge and products but also new networks, policies, rules/institutions and communal relations. Roadmaps are important but each community need also to find and integrate the most suitable elements and collaboratively construct their own path for the journey towards energy smart cities [8]. How can a medium sized city manage its sustainable innovation journey to reach the forefront and leading edge on the road towards becoming an Energy Smart City?

Existing research on sustainability planning and transition [9] as well as experience from the PLEEC cities indicate that a strategic orientation involving the following factors is important:

- Broad engagement of different stakeholders across sectors in working with sustainability innovation
- Coordinated multi-level work among a network of community actors horizontally as well as vertically where top-down policies meet bottom-up initiatives
- Looking ahead having a long term perspective on transition beyond short term goals
- Shared visions which guide the work of community actors
- Political commitment and support for sustainability innovation, implying that it is politically legitimized and embedded in existing policy-making frameworks
- Resource availability and mobilization for investments and development work, such as finance and expertise
- Nisches, spaces and sites for experimentation with new and alternative energy solutions. Experimentation can help explore a wide variety of options, both incremental and radical, which when proved their worth can accelerate the transition process
- Ascertained dynamic mechanisms of change making sure that efforts persist even though immediate results are not materializing or setback occurs. This can be done by establishing innovation management capabilities in terms of good practices, competencies, relations and routines.

In assessing innovation management capabilities in the PLEEC cities, an established assessment model from innovation management research field has been used [10] comprising five innovation capacity dimensions (strategy, organization, processes, linkages, learning), specified in a set of innovation practices which enable innovation activity and management. The assessment model is adapted to community level and the context of transition to Energy Smart City based on research on sustainability transition dynamics, strategy and management. The finding shows that city planning need to deal with a number of concrete challenges experienced to consider in innovation and transition work, evidenced in the PLEEC cities. Table 1 points to main challenges and develop proposals and what city planning can do to deal with them. In the table, the challenges and innovation enabling measures are connected to main innovation capacity dimension(s); strategy (S), organization (O), processes (P), linkages (L1), and learning (L2).

Table 1. Challenges experienced to consider in innovation and transition work, evidenced in the PLEEC cities and research literature

Challenges in innovation and transition work	**What can city planning do**
Varied situations and historical paths conditioning opportunity space and obstacles for sustainable development	Further strategic analysis and scenario development of city conditions and alternatives through workshops, communication, simulation etc. (S)
Low priority on agenda of sustainable energy use by leading community actors	Communicative and symbolic initiatives of urgency, appoint sustainability transition officer. (L2)
Short term thinking (business, politics, citizens) in sticking to status quo or energy wasting innovative behavior	Collaboratively engage in exploring and committing to a future sustainable city. (S, L2)
Uncertainty of eco-investments, particularly systemic innovation	Reduce uncertainty and risks for individual actors to be active innovatively, and support development of workable business models. (P, S)
Low eco-innovativeness of citizens	Build niches and sites for eco-creativity and innovation, e.g. in Innovation Parks, experimentation areas, schools and universities. (P)
Scarcity of resources for eco-investments	Creative work in fundraising (e.g, national, corporate, EU), and through collaboration (e.g. with business and citizen groups). (S, L1)
Fragmented policies and action, limited coordination	Further interaction, communication and cross-sectorial collaboration, e.g. in PPPs, social contracts or sustainability procurement (O, S)
Limited common long term visions and commitments	Political work by citizens and leaders for city vision and mission creation and development of sustainability transition planning. (S)
Limited processes and procedures for innovation	Further/use project models and evaluation which incorporates sustainable innovation. (P)
Institutional and cultural barriers in innovating more sustainable technologies/practices	Further demonstration of good practices, incentives for innovators/early adopters. (L2)
Benefits/costs not integrating sustainability effects (too narrow system boundary)	Support communal/circular cost/benefit thinking, analysis and action. (O, L2, S)
Actors causing sustainability problems has limited responsibility for innovating sustainable solutions	Local regulation, subsidies and procurement to enable/enforce responsibility, e.g. wasteful or unsustainable energy consumption. (S, O)
Infrastructure lock-in and lock-out (technology, structure, culture) hampers new sustainable solution which do not fit existing system	Help to further appropriate city infrastructure for new more sustainable energy solutions, e.g. electric transportation vehicles, experimentation sites to find locally fitting solutions, sustainable life style marketing. (S, L2)
Limited authority/power and expertise to influence e.g. national/international/ market/business/culture in eco-innovation	National lobbying, national and international networking, alliances and collaboration. (L2)

4. A practical example; an electric pedal hybrid vehicle (EPHV)

We will use an example from PLEEC work to illustrate how available technology potentials meets with these innovation challenges. Decreasing and replacing fossil fueled transportation is crucial in the sustainability problematique [11, 12, 13]. Electrical vehicles are here worldwide analyzed and experimented with as an alternative [14]. It is also important to use the creativity of the population in innovative efforts. One way for this is to get students at all levels to discuss different alternatives and also implement when possible. At Mälardalen University in Eskilstuna this was done by letting students construct a simple vehicle that could be used to replace a car in the city. A three wheel bike was covered by plastic to protect from wind and rain. The total cost was around 1500 € which normally is feasible for most people to afford. The vehicle can operate at maximum 25 km/h which of course is low compared to a car, but considering the average speed in cities which is around 15 km/h including queuing, it is reasonable. It is also easy to park as very small dimensions and the cost for electricity is very low and the battery can be brought up into the apartment or office for charging, which makes fast charging unnecessary. The battery supplier said the battery would give a transport distance of 40 km, but in reality it was approximately half with this Li-ion battery when the students tested the practical performance. We have seen the same relation for Lead –batteries as well. Then it is very good to have the pedal function, so that you are not stuck somewhere where you don´t want to stay. This is very good in relation to fully electric cars, and is more like hybrid electric cars. These on the other hand normally use fossil fuels as back-up system to the electric engine, which is not the case for the pedal-hybrid.

For the students in the project the task was both to actually design and build the vehicle, which gives you a good understanding on constructions in practice, but also the students where testing the performance of the vehicle under different conditions, and thereby gave us a good understanding of limitations for electric vehicles. The students also compared infra structure needs for such a vehicle compared to fully electric cars with fast charging, and also compared to "normal" fossil fueled cars used today. The biggest positive effect is that the cost for operations is almost negligible for the electricity compared to petrol or diesel, and for the pedal-hybrid also the investment cost is very low. Some issues though are there like how to protect the vehicle towards thieves and where to park. You don´t want to pay full car price for a vehicle occupying 1/3 of the space.

The project explored a technological potential in transportation by way of a fossil-free, low cost and healthier vehicle. The electrified tricycles can in a general perspective be analyzed as having several advantages in achieving better systemic performances [15]. People can transport themselves and their goods conveniently, very much cheaper than cars and with very limited environmental effects, requiring much smaller lanes and parking slots. E.g. short distance transportation for shopping, smaller utilities or job travel can be seen as ideal areas of use, which covers a significant part of transportation needs. Fueling is of course an issue, but it can use more limited equipment than what is needed for electric cars, and can use today's electricity system. It certainly do not need such big investment in upgraded electricity systems and vehicles as the one pursued by Tesla. Thus this technology seems to have considerable potentials in a future sustainable transportation system. Furthermore, pedaled rickshaws, now also electrically assisted, have a long history of use in China, India and other Asian countries, so why not in western cities? Analyzing this technology from an innovation perspective, it shows that many, even most, of the innovation challenges described in table 1 is evident for these western variant of rickshaw, e.g. infrastructure lock-out, institutional and cultural barriers, no strong support by committed and powerful actors, the need for regulation etc. [16], indicating a varied agenda for active city planning activities. Main innovation strengths is its limited need for investments in the technology itself, and its basis in large part known technical features already in use. But recognized as involving systemic innovation [17] in many respects, its implementation can be recognized as a complex innovation journey [18, 19]. Western city transportation system is dominated by larger motorized vehicles, electrified rail systems, bicycles lanes and walking areas. Rickshaw type of vehicles do not generally fit in as it is too big for bicycle lanes and considered unsafe accompanying larger vehicles on roads. Institutionally it need to fit into regulatory systems, and culturally people are quite unaccustomed to these type vehicles. Today there is in European cities a bicycle lobby (it is evident in the PLEEC cities, were all want to improve the share of bicycling in city transportation) struggling to get a better standing and space in relation to dominant motorized infrastructures, but this type vehicle do not (yet) have similar support. Further, it has to be adapted to its specific uses and conditions in the local transportations system of cities in order to be considered as a sufficiently good transportation solution for its citizens. Based on these (and more!) challenges, our development experience with EPHVs shows that there is a need for several innovation efforts in parallel in order to support an implementation of these type of vehicles in western cities.

5. Conclusion

There are today a considerable array of available technological potentials for sustainability transition of cities. If available best practices could be implemented, all or at least a great part of our sustainability problem could be resolved. At the same time there are huge challenges in managing innovation processes in cities so as to realize these potentials in embedded, efficient and sustainable energy systems, as shown by the findings from a study in the PLEEC project. How technological potentials is enabled by innovation capabilities and how various innovation challenges are met with in city planning is analyzed in the paper and illustrated in the case of an electric pedal hybrid vehicle. It shows that the transition to energy smart cities is a complex, systemic innovation journey where also seemingly simple technical solutions, like in the EPHV example, are facing many-sided innovation challenges requiring a spectrum of city planning measures.

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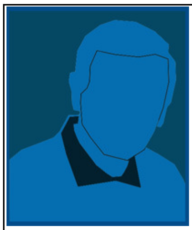

Biography

Erik Lindhult is Assistant Professor at Mälardalen University in Sweden at the department of Innovation Management His main research interest is systems and complexity approaches to innovation and its management, sustainable innovation and entrepreneurship, industrial service innovation as well as value driven innovation.