Energy Efficiency in Hammarby Sjöstad, Stockholm through ICT and smarter infrastructure – survey and potentials

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ABSTRACT

Internationally, Stockholm's brownfield development Hammarby Sjöstad is seen as one of the world's highest profile examples of Sustainable City Development. Is its energy efficiency already optimal, or is there an untapped potential for "Renewing a New City", for example through the innovative implementation of ICT? This is the main issue of the study reported in this paper.

In the mid 1990s, after some five years of comprehensive planning, the City's politicians and leading officials agreed that Hammarby Sjöstad should be the Olympic Village when applying for the 2004 Olympic Games. To strengthen the application, an environmental programme was passed in the city parliament, a project team comprising representatives of the main city administrations was established, and the team was given the task of injecting the novel features of the programme into an ongoing, ordinary planning process [1, 2]. In 1997, the Olympic committee gave the Games to Athens. Nonetheless, the environmental programme and the project team were retained, and for more than a decade of construction the area has been marketed as a spearhead of urban sustainable development [3, 4]. However, evaluations indicate that its energy efficiency is average if benchmarked towards other developments of the same period [5]. Dispersion is wide, a factor three.

As part of development, the national government subsidized a number of projects to support the environmental profile, some of them being targeted towards ICT and "smart homes" technology [6, 7, 8, 9]. This is interesting, since it is often argued that the innovative application of ICT should markedly increase energy efficiency [10]. In research at KTH, Stockholm, we therefore explore this as applied to Hammarby Sjöstad: To what extent do systems rely on smart infrastructure to control energy use and its impacts – in the electric system, in the district heating? Does ICT integrate citywide and local energy system components through automation, does ICT interact with operators, managers or residents, informing or persuading them to be energy efficient?

For the purpose of this study, smart infrastructure is defined as systems that make it easy for users and managers to keep energy use and its impacts low, without compromising utility or comfort Data is collected from documents and interviews. Eight real estate units with elements of smart infrastructure were identified. Thus, about 5 per cent of the flats have this feature, mainly to automatically integrate novel components such as photovoltaics or geothermal energy into the large-scale ordinary energy systems. There is also a single example of a passive house. This is the only Sjöstad real estate unit to comply with the original energy objectives of using no more than 60 kWh/m^{2}yr.

The addition of local energy sources to a large-scale energy system influences the routines of operators and managers, introducing an element of smartness. It was also found that in a few cases, buildings were provided with "smart homes technology", i.e. ICT that actively interacts with the residents. However, findings indicate that some of the technology does not function properly or has already become obsolete. In three cases, managers and owners are ignorant whether an element of smart infrastructure is operational or not. On the other hand, already from 2000 on, the district was provided with a comprehensive fibre network, which is still up to date. From this follows that on district level the potential for smart infrastructure is there, but as mentioned it is only in part utilised in the individual buildings.

Keywords

Hammarby Sjöstad, Stockholm, smart infrastructure, energy efficiency

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1. INTRODUCTION

Hammarby Sjöstad is a new city district just south of central Stockholm, which is internationally known as an outstanding example of urban sustainable development [see e.g. 3, 4]. Planning started in the early 1990s and construction will continue until about 2017. The area's environmental profile was introduced into the planning process when the City Parliament passed a comprehensive Environmental Programme in 1997 as part of the application for the Olympics of 2004 [11]. Energy use and its impacts remain one of the programme's main issues. Common opinion has it that local energy sources supplement the large-scale electric grid and the district heating system, providing part of the electricity and the energy for heating, and that smart homes technology is installed in pilot projects. To what extent, then, has ICT been used to help managers and users in keeping energy use and its emissions low? Given this, which is the potential for improvements? These are the main issues addressed in this paper.

A more precise wording would be: In what buildings, for what purpose and for whom is ICT incorporated as part of a smart infrastructure in the buildings of Hammarby Sjöstad? From this, two conceptual/theoretical questions follow:

- Which is the definition of smart infrastructure for the purpose of this paper?
- Which is the definition of energy efficiency, in such a smart infrastructure system?

Four empirical questions follow, too:

- In what buildings of Hammarby Sjöstad are smart infrastructure systems found? Is there some smart system infrastructure for the district as a whole?
- What novel components (for example ubi – ubiquitous computing) does ICT integrate into these systems?
- To what extent and how do the systems interact in novel ways with their managers and users via ICT?
- What actor(s) could utilise an untapped potential for improvement in energy efficiency and its impacts, if any?

Furthermore, this wording indicates a number of delimitations:

- Geographical system boundaries are those of Hammarby Sjöstad, and in particular the smart infrastructure of its buildings. Regional or national infrastructure is not considered, although it might be a prerequisite for local smartness.
- Systems include those providing electricity and energy for heating and hot water. The water-sewage system and the transport systems are excluded.
- ICT or the smart systems' contributions to energy efficiency are not evaluated, nor are the untapped, future potentials for increased efficiency assessed.

In the following are presented some preliminary findings from an ongoing study addressing the aforementioned issues. On the one hand, it is an extension of previous research on the environmental management of Hammarby Sjöstad [1, 2] and on scenarios for urban sustainable development in Stockholm [12, 13]. On the other, it is intended to give input to an upcoming study on attempts at increasing energy efficiency in Hammarby Sjöstad – "Renewing a New City" [14].

Data for the study come from research-based documents, and from documents of the City's and the national government's involvement in Hammarby Sjöstad. It was not deemed necessary to send out a survey to all real estate owners of Hammarby Sjöstad in order to identify the buildings that have smart infrastructure. Instead, the initial selection was based on information from the officers of the Sjöstad information office GlashusEtt, from documents and the Internet. With one exception, all buildings included in the study are at present owned by the residents in the form of housing co-operatives (Swedish "bostadsrätt"). Most of these have home pages of their own, from which minutes from annual meetings and other information can be obtained. Furthermore, officers at GlashusEtt were interviewed. At present, the real estate owners and managers of the area are interviewed, but some of this data is still missing. Data is analysed using ordinary methods for qualitative research. Validation is mainly through data triangulation [15]. Being a case study, it relies mainly on the reader to apply the findings and conclusions through so called naturalistic generalisation [15].

2. BACKGROUND AND THEORETICAL CONSIDERATIONS

Hammarby Sjöstad is an extension of Stockholm's inner city towards the south. Construction started in 2000, and when fully developed in 2017 the area will have 11,000 flats for 25,000 residents and at least another 5,000 workplaces. Comprehensive planning focused on its waterside setting, development is transforming an old industrial and harbour area into a modern environment with a distinctively urban character, also utilising its location near the Nacka nature reserve [3, 4].

The overarching aim of Hammarby Sjöstad's Environmental Programme is that the area should perform 'twice as well' as ordinary new housing of the time [11]. The programme comprises objectives under six main headings:

- Land use
- Soil decontamination
- Technical supply: energy, waste and water-sewage
- Transport
- Construction materials
- Noise

For each of its main headings, the Environmental Programme has a descriptive and argumentative part. In an appendix, the objectives are quantified as 'operative guiding aims', mainly in relative terms. However, the objective for energy is absolute: 'The total need for supplied energy should not exceed 60 kWh/m^2' [11]. The programme also comprises social and economic objectives, but these are not as concrete as the others, nor as comprehensive. The area's performance in relation to the operational goals was evaluated by Pandis Iverot and Brandt [5]. The average energy use was found to be about twice of that of the original objective, with a factor three dispersion.

Like any other city, Stockholm has an electric grid connected to the national one. Supply is roughly half-half from nuclear and hydropower with negligible contributions from wind and sun [16]. Unlike cities in most other countries, however, Stockholm provides practically all of its buildings including those of Hammarby Sjöstad with energy for heating and hot tap water via a citywide district heating system. In parts of the city, also district cooling is provided.

In parallel with the environmental programme, a model for the integrated infrastructure systems of Hammarby Sjöstad, the Hammarby Model, was developed [17]. In fact, it is in all essentials the infrastructure systems for energy, water-sewage and waste of all of Stockholm. From this follows that it is not unique for Hammarby Sjöstad or in relation to ordinary Swedish practice. On the other hand, it is out of the ordinary in an international perspective, firstly since it includes a city-wide district heating system based on waste incineration, heat pump technology etc., secondly because integration through city planning is extensive. For the same reason, it has few elements of smart infrastructure, following the definition of this paper as given in the following.

In spite of the Hammarby Model's systems on the whole not being smart, ICT is obviously used to control their energy flows. However, when new energy sources such as solar panels or photovoltaics are introduced, more sophisticated ICT is needed, making the system smarter by definition. The same applies when developers, contractors, users or managers want better-than-average control of energy use. Examples of this type of possible improvements are weather prognosis based, automatic control of the heating system, or usage and price information provided to the residents via smart meters. Internationally, a number of innovative ICT applications for energy efficiency are in the pipeline. In Stockholm, a smart electric grid is planned for the next large brownfield development, the Royal Seaport. For an overview of established as well as visionary applications including novel forms of human-computer interaction and ubiquitous computing, see the findings of the REEB project [10].

For the purpose of this study, the concept of smart infrastructure was coined. It indicates the aforementioned system properties. The ICT part of the smart infrastructure can integrate novel components with an ordinary energy system in to an optimized whole, for example solar panels into the heating system. It can also interact more or less intensely and frequently with its user – it can automate, inform or persuade. Automation means that once the system is set up, interaction is essentially restricted to malfunction alerts. Information can be provided to the operator or manager of the system on momentary or long-term use, benchmarking against others' systems, cost etc., and also on similar issues to the users. Persuasion uses information for an explicitly normative purpose, here that of reducing energy use and its impacts. It can be low-voiced and mainly based on information, for example through benchmarking with similar users; it can also be provocative, such as the red light that turns on after five minutes of hot shower [18, 19]. Especially in rented property and when installed by the manager of flats that are already occupied, personal integrity becomes an issue [18].

Based on the above, the concept of smart infrastructure can now be defined as:

Smart infrastructure makes it easy for users and managers to keep energy use and its impacts low, without compromising utility or comfort.

The search for smart infrastructure in Hammarby Sjöstad thus focuses on buildings in which ICT integrates new technology such as solar panels into an ordinary energy system, or interacts in new ways with a human being such as the system operator or the resident. District-wide components such as a comprehensive network are also sought for.

Accordingly, energy efficiency here means "keeping energy use and its impacts low". As mentioned, no quantification beyond a few key ratio figures is provided. However, while ordinary statistics uses key ratios such as kWh or CO_2 emissions per square metre, the ambition in the further reporting of this study is to provide what quantification there is as energy use and CO_2 emissions per person. After all, it is the residents who benefit from the utilities and comforts provided by supplying energy resources to the buildings.

3. RESULTS

In the following, preliminary findings are presented under the headings of Buildings and District, respectively. At the time of writing, some interviews were not finalized.

3.1 Smart infrastructure in buildings

Elements of smart infrastructure were found in eight of Hammarby Sjöstad's real estate units, with a total of ca. 500 flats. This is about 5 per cent of the total number. In three of these units, the element of smartness consists of the integration and ICT-based control of one single local energy source. In real-estate units Fjärden 1 and Grynnan 1, photovoltaics were installed to provide part of the electricity for lighting in stairwells and other common areas. Both units were constructed in the early 2000s. According to recent communication concerning Grynnan 1, neither its board members nor the manager know if the photovoltaics are still operational. An office building completed in 2011, Mältaren 3, has a geothermal system for heating and the necessary control system as its element of smartness. In all these cases ICT is essentially used to automate the integration of local and large-scale energy sources. The sources do not indicate that these elements of smartness reduce energy use, but all of them produce renewable energy.

Around 2000, a competition for "Best Building" was arranged, with the assessment criteria of reduced environmental load, good residential quality and low life cycle cost. All of the awarded buildings show more than one element of smart infrastructure. In the following, each winner is presented separately. Unless otherwise stated, the main source is the report on the competition [7]. Information centre GlashusEtt provided additional documents and information from interviews with staff. The competition was judged from the designs, from which follows that possible changes during construction and management had to be identified through interviews.

Holmen, winner of the first prize and developed by contractor NCC as a housing cooperative has photovoltaics according to the competition documents. Smart infrastructure elements furthermore comprise heat retrieval from the sewage water and the exhaust air, and ventilation is individually controlled for each flat. ICT is also used for "Monitoring, operation of technical systems and indoor climate…" [7]. Thus, an out-of-the-ordinary element of interaction with the building's operator, manager and users is included. Furthermore, the share of energy purchased from the large-scale systems is reduced, and the share of renewable energy is higher than in a similar ordinary system. However, according to an interviewee, the cooperative's board has no knowledge of the sewage heat retrieval, nor of the individually controlled ventilation, and the photovoltaics gradually deliver less energy. The ICT-based monitoring system was just prepared for, but the board plans to install one in the future.

The second prize winner, Kobben, was developed by SBC Bo, also as a housing cooperative. According to the competition report

[7] it has an integrated combination of solar panels and photovoltaics; furthermore fuel cells and "Heliostats and holographic materials in railings". The latter as well as the role of the fuel cells are not described in detail, just mentioned as parts of the energy system. Instead of radiators it has underfloor heating and the ventilation system is said to be "electro-efficient". Except for the ventilation, all components are integrated into the ordinary energy systems by ICT. Finally, each flat has a computer screen for interaction with the residents. However, interviews indicate that today some of the features are not there: The fuel cells were never put in place. Only in 2005 were the combined solar panels-cum-photovoltaics installed, and in parallel evaluated [20]. It was found that such a large share of the photovoltaic cells were damaged that proper measuring could not be done. Furthermore that the control system for the solar panels (i.e. the ICT, its sensors and other control equipment) was incorrectly adjusted and thus provided only a low temperature contribution. The real estate owner, a housing co-operative, was recommended to do a proper adjustment of the heating energy system. Finally, interviews indicate that the residents' screens were disconnected by mistake and have not been operational since then.

Municipal housing company Svenska Bostäder won one of three third prizes with their real estate unit Viken, recently sold to the residents in the form of a housing cooperative. This project is provided with heat retrieval on the exhaust ventilation, solar panels and fuel cells. ICT integrates novel and ordinary components of the energy systems. Viken was also provided with an ICT system targeted at the residents and providing information to "Facilitate the choice of environmentally adapted transports" [7]. A system for follow-up, control and cost allocation for energy and water was also provided. In this case, interviews are needed to ensure what was implemented and what is still in use.

Another third prize was given to municipal housing company Familjebostäder for Lugnvattnet, which also recently became a resident owned housing cooperative. Unlike the others, this competition entry is but part of a larger real estate unit, a small tower block of eight flats. Smart components of the heating system include a geothermal heat pump and a biogas boiler. The façade and the roof have photovoltaics. Ventilation is said to be "electro-efficient" but it is not stated to what extent this involves ICT. The flats are provided with underfloor heating. The documents do not mention any novel elements of information provided to operators or managers in relation to these components, so here ICT has the role of automation. On the other hand, residents are informed of the use of electricity and energy for heating and hot water on a display mounted in the entrance of the building. If interviews confirm that these elements of smartness are still in use as intended, the share of energy purchased from the large-scale systems is reduced, and the share of renewable energy is higher than in a similar ordinary system.

In 2010, private developer ByggVesta completed what is arguably Hammarby Sjöstad and Stockholm's first building to comply with passive house standards, Kajutan 2. The developer claims that the concept "…cuts energy consumption by 50% compared to the requirements stipulated by the Swedish National Board of Housing, Building and Planning for blocks of flats. And this is achieved at the same production costs as with conventional construction." [21]. At 55 kWh/m^2 and year, this concept makes Kajutan 2 twice as energy efficient as the Sjöstad average, and the only building in the area that reaches the original energy objective. Although it has the main characteristics of a passive house, ByggVesta labels the energy system as a "Self-heating Building" ("egenvärme" in Swedish). One main difference from ordinary buildings is its extremely well-insulated and leak-free climate shell, which in itself is not part of a smart infrastructure. However, it enables the heat from residents and appliances to become the main source of energy for heating. Additionally, the ventilation system has heat retrieval, and the system is connected to Stockholm's district heating as backup and for hot water provision. Integration and control of these sources call for ICT automation that all in all make the system smart infrastructure. Another feature which is not common practice in Swedish multi-family housing is the individual measuring and charging of hot tap water and heating besides conventional charging for electricity use. This, too, calls for an element of smartness in the systems. There is, however, no mention in the documents of information or persuasion targeted towards the tenants.

Findings so far can be summarised as follows: Eight real estate units with a total of ca. 500 flats have elements of what is here defined as smart infrastructure. Six of them are now owned by the residents in the form of housing cooperatives, one has right of tenancy and one is an office building. The housing cooperatives were built in the early 2000s, the other two during the last few years. Only one of the present owner/managers claims that the building is more energy efficient than the average Sjöstad building. In few cases is it explicitly argued that the photovoltaics, the geothermal energy, the biofuel boiler etc. reduce the level of CO^2 emissions, although this should be the fact. In three cases, the element of smartness is restricted to the integration of one local energy source. On the main, the smartness takes the form of automation, with only 1-2 identified cases of smart interaction with managers or users. What was in the competition designs was in some cases never installed: One of the cases got no fuel cells, another no heat retrieval from sewage. In one case the interactive ICT for management was just prepared for, in another it was accidentally disconnected. One set of photovoltaics was defective from the start, another shows signs of ageing. Finally, there are gaps in knowledge transfer from construction to today's owners and managers concerning for example if the photovoltaics are still operational.

Referring back to the definition of smart infrastructure, it remains to ask: Does what there is of smartness provide a good indoor climate? In documents, the indoor climate in some flats has been criticised: It is too hot in summer, too cold in winter; the need for cooling has been discussed. However, this is in the first hand a consequence of the design programme of Hammarby Sjöstad: Lake view and large windows were given higher priority than energy efficiency, and the resulting consequences for the indoor temperature were not fully considered [1]. The connection to (lack of) smartness cannot be established.

3.2 Smart infrastructure in the district

As part of national government subsidies for Hammarby Sjöstad, four projects that relate to smart infrastructure were funded. They were initiated around 1999 and reported in 2004 [6]. Three projects focused on technology for Hammarby Sjöstad buildings, the fourth on district-wide infrastructure connecting the buildings.

A technology procurement of individual metering of heat, electricity, gas and water was undertaken. In the report [9], it is said that already around 2000, 500 flats were thus equipped, and that if metering was not installed, the infrastructure was prepared for it. The report does, however, not indicate if new forms of ICT-based interaction with the residents is involved.

A second project was the technical procurement of solar panels, with the aim of procuring more cost efficient and technically advanced systems. Procurement was, however, discontinued since the real estate owners showed little interest [22].

A pilot study explored the conditions for technical procurement of Smart Homes technology. The conclusion was that it was difficult to find technology “with clearly resource saving effects” [23] besides what had already been procured. Therefore, no additional procurement was initiated.

The fourth project was about the whole district’s basic ICT infrastructure. According to the report, it had a main aim similar to that of this study’s definition of smart infrastructure: “…help creating an ICT infrastructure that will help people in the area to obtain a more energy efficient and environmentally adapted way of living and working.” [8]. To this end, there was a need for coordination of communication services such as telephony, cable TV, Internet access and real estate operation over one common infrastructure. In parallel, a novel business model was deemed necessary. It was argued that coordination would give large positive effects, through the substantially reduced technical infrastructure (reduction by 70-90 per cent), as well as through more efficient use and operation of the system. In the report, published when roughly one fifth of the total building stock was built, it is confidently stated that “We hereby establish that this aim to a large extent already has been attained.” [8]. Recent documents from the infrastructure manager indicate that coverage during the later stages of the Sjöstad development remains high [24].

In the project, technology procurements included a fibre network for all buildings, active network equipment and a local Web Portal. The system’s service provider was also established through procurement. For the management of the system, an association, “Hammarby Sjöstad Ekonomisk Förening” (HSEF), was founded, which still manages the ICT infrastructure of the district [24].

One ambition in the project was to provide optimized operation of the energy systems and the ventilation, assumedly saving around 10% energy. Utilisation lies of course in the hands of the owners, managers and residents of each real estate unit. No evaluation has been made, but based on the unremarkable energy performance of the average Sjöstad building, it can be assumed that this potential remains largely untapped, be it smart or not by the definition of this study.

The local Web Portal, www.hammarbysjostad.se, is today managed by the officers of GlashusEtt. It presents itself as “the environmental web portal of Hammarby Sjöstad” and is in the first hand developed to interact with the local residents. The ordinary information material also provided at GlashusEtt can be found here, as well as everyday “environmental tips” that are regularly updated. There are also login pages dedicated to the local residents and to the area’s housing cooperatives. In the 2004 report, [8] it was suggested that the portal should also provide links to the travel planner of regional public transport company SL and to the local car sharing pool. However, the portal visitor of 2012 will not find such links. Nor does the portal provide internet-based local shopping as proposed in the report.

To summarise: Hammarby Sjöstad as a whole has a uniform standard of ICT infrastructure on district level. This provides the district with a range of potentials for energy efficiency, in the buildings as well as for transport and other types of energy use. However, according to the definition used in this study, it is in the main a potential, with one exception: Information targeted towards local residents is realised smartness, since it interacts with the users about energy issues; but only when the ICT infrastructure in the buildings has hard- and software to automate, inform or persuade via the district infrastructure, the latter becomes smart. And this, as has been shown, is largely not the case.

4. DISCUSSION AND CONCLUSIONS

This paper presents preliminary findings of a study with the aim of investigating in what buildings, for what purpose and for whom ICT is incorporated as part of a smart infrastructure in the buildings of Hammarby Sjöstad. Based on a the aim, the key concept was defined thus:

Smart infrastructure makes it easy for users and managers to keep energy use and its impacts low, without compromising utility or comfort.

Based on this definition, smartness was first discussed in terms of ICT integrating novel components into ordinary large-scale energy systems for electricity and district heating. It was found that to a high extent, integration is automated. Smartness lies also in ICT interacting with its users in new ways, providing information or persuasion. The integrating hard- and software for automation will retain the intended level of energy efficiency, once it is set up and functioning. Unlike this, the energy efficiency based on interaction will have to be continuously reproduced: Although the information is there, the user might over time disregard or forget about it. Thus, interactive ICT in smart infrastructure enables energy efficiency but does not provide it.

In all, eight buildings with elements of smart infrastructure were identified. Thus, 95 per cent of the total number of flats in Hammarby Sjöstad rely on ordinary ICT for the integration of system components, and likewise ordinary ICT-based interaction with managers and operators. Even less of interaction with residents was found. Unlike this, the district-scale system as implemented covers the whole district. When implementation started, it was certainly out of the ordinary, in technology as well as in its business model. In 2012 this technology has become standard in construction and in the existing building stock. However, this does not make it less smart. As previously argued, the district infrastructure is not smart in itself, only when used to reduce energy use and its impacts in the buildings. Thus the two system levels are mutually dependent.

As mentioned, previous research shows that on the average the energy efficiency of Sjöstad buildings is the same as that of other buildings from the same period of time [5]. If energy use for heating and hot water is measured in terms of kWh per person and year as suggested in the paper’s discussion on energy efficiency, it can even be claimed that it is no better than the average of nearby city district Södermalm, which comprises building from the 17th century on, with a predominance from the early 20th century. The reason is that each resident of Hammarby Sjöstad utilizes ca. 30% more of heated area than the average Södermalm resident. The solar panels and photovoltaics, the geothermal heat and other local energy sources should reduce the share of CO_2 in energy production, but not noticeably so if measured on district level.

Some of the designed smartness was never installed, a few elements were defective or have become outdated. Board members and managers in three of the studied housing cooperatives are uncertain if part of their smart infrastructure is functioning as intended. The obvious conclusion is that the infrastructure needs maintenance and development if it is to stay smart, new managers and users need education to utilise the potential smartness. Furthermore, smart homes technology with short service life was integrated into the buildings' walls that have a very much longer service life, without due consideration on how to dismantle the former.

On the one hand, this can be seen as a criticism of the City planners and the developers, consultants, contractors etc. involved in the development of Hammarby Sjöstad. Obviously, they did not succeed in realising the energy objectives given by the City Parliament, be it with or without smart infrastructure. However, this must be understood in the perspective of the Environmental Programme being introduced into an ongoing planning process, with already well-established routines [1, 2].

On the other hand, this indicates that there is a vast untapped potential for improvement. This might be seen as unrealistic in a recently constructed area: Climate shells to passive house standards will not be on the agenda until renewal of the buildings is due in 20-40 years from now. On the other hand, optimisation and gradual improvement are feasible; new ICT components can for example be introduced in existing energy systems to increase ubiquity and human-computer interaction. More of local energy production also leads to increased smartness. The large-scale infrastructure is there and operational, the cost can be assumed to be acceptable [10]. Inertia rather lies in the lack of an obvious initiator or demand shaper [25].

The responsibility for realising the smartness potential in the building stock belongs to the real estates' owners, managers, operators and users. In a majority of the Sjöstad buildings, the owners and users are the residents, in association in their housing cooperatives, and as individuals or household members in each flat. In other words the residents – as households and in association – are the primary demand shapers. However, as laymen in real estate management, they purchase management services from professionals. Thus, the demand shaping initiative lies in the relation between the laymen owners and the professional managers. Organised collaboration between real estate owners could also contribute.

Hammarby Sjöstad has a citizens' initiative, HS2020, which seems to have the resourcefulness needed. This initiative has as its basis an association of the area's housing cooperatives, and from it stems the catchphrase "Renewing a new City".

In future research, HS2020 as coordinator of demand shaping will be studied. It can be assumed that on the supply side, neither HS2020, nor the manager of the district fibre network, HSEF, nor a single ICT company could on its own provide the consultancy, the installation of hard- and software etc. needed to make the Sjöstad's energy systems smarter. However, business models built upon collaboration between companies providing the different components of a whole seem feasible. This would provide the real estate owners with a single supply side partner. In Stockholm City's new sustainability project, the Royal Seaport, actors collaborate in a similar consortium to implement a smart electric grid [26]. In fact, representatives of the citizens' initiative in Hammarby Sjöstad already have contacted the Seaport consortium.

The potentials of smart infrastructure are largely untapped in Hammarby Sjöstad, but because of that the potential for increased energy efficiency is there. If the concept of "Renewing a new City" gains momentum and its propagators succeed in involving the real estate owners, residents and other actors needed, more of this potential could be realised.

5. ACKNOWLEDGMENTS

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