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Negotiated Outcomes – Actor-oriented Modelling of Energy Efficiency in a Stockholm City District Renewal

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Abstract: "What if the renewal of Rinkeby-Kista, Stockholm, were to make it part of a 2 kW Society?" Renewal of the city district's 25 000 flats from the 1970s is due and a network organisation, "Järva Boost" is established. A cross-disciplinary team of KTH researchers develop a computerised model to simulate energy efficiency gains resulting from actors' decisions. Inputs are measures that building owners, energy providers, residents, planners etc. might propose. They can be technical institutional or socio-cultural. Outputs are energy use in kW/person and CO_2 emissions. To guide model development, an "ideal type" usage situation is outlined. The energy system is modelled "upstream" from end use, to identify larger efficiency potentials. The model interface is designed to enable the "staging" of actors' negotiations: The manager influences the properties of the climate shell, the residents the energy used for cooking, and the energy provider the primary energy mix. The concepts of "Household Activities System" and "Energy Usage Systems" give theoretical framework for modelling. The former conceptualises residents' activities, the latter the technology providing services to the activity. Simulations give contrasting outcomes: "business as usual" vs. ”most favourable". Used in practice, simulations might simplify negotiations and coming to agreement.

***Keywords**:* Energy systems modelling; actor participation; Stockholm City district; usage situation; Energy Usage System.

1 INTRODUCTION, RESEARCH QUESTIONS AND METHODOLOGY

1.1 Introduction

The Stockholm City district of Rinkeby-Kista is due for renewal. Like any planning process, it is a complex interplay between public and private actors – real estate managers, city planners and other local authorities, consultants and contractors, energy providers, residents etc. In part, it is an exercise of public authority, but largely the actors negotiate to resolve conflicts, make informal agreements and sign contracts. In an ongoing research project this specific planning process was the point of departure. We added a counterfactual element, asking: What if increased energy efficiency and reductions in CO_2 emissions were as high on the actors' agenda as restoring technical properties and increasing socio-cultural sustainability? From that assumption, we built a futures studies scenario of the district 15-20 years from now, exploring the opportunities of the situation. A main purpose was to use scenario development to study the field of options of a process of *negotiating sustainabilities* among the actors [Svane 2011a]. As part of scenario evaluation, we needed to simulate the outcomes of such negotiations, quantifying energy efficiency and CO_2 emission potentials. We also wanted to do it as a series of role games, in real time. The options were either to adapt a computerised model found on the market, or to develop one of our own.

Based on literature reviews, in-house development was chosen. We identified a computerised tool to support modelling, and decided that the cross-disciplinary learning potential was worth the extra effort. Through the reviews we also identified two areas where a model needs properties that go beyond those of existing tools. First it should enable the clear distinction between scenario elements such as:

- measures taken, e.g. the renewal to passive-house standard or the implementation of individual charging of energy use, and
- ongoing activities in the buildings, e.g. cooking or leisure.

In sociology's structuration theory, the former are changes of the physical and institutional structures, the latter the human activities as influenced by (and influencing) the structures [Giddens 1991]. In the DPSIR system, as developed by the European Environment Agency [EEA 2003], they are labelled as Responses and Drivers, respectively. In a scenario, both can be objects of change.

Second, the model should incorporate the perspective of negotiating sustainabilities in terms of explicit agency or governance. Which actor can take what action? How do actors need to collaborate to make things happen? In the Rinkeby-Kista scenario, agency is explicit; for each measure, such as for example the improvement of the climate shell or the reduced use of hot water, the main actor (the building manager and the resident, respectively) is indicated. However, the literature reviews indicated that this perspective is seldom explicit in the futures studies' scenarios of others [Wangel 2011].

Thus, in this paper we discuss what properties a model needs in order to enable:

- the modelling of a scenario exploring the renewal of a city district, transforming its structures and indirectly influencing its users' everyday activities, and
- real-time simulations of the outcomes of negotiating sustainabilities' role games.

To justify the effort of in-house modelling, we strived for a model that represents the Rinkeby-Kista case as well as other, similar scenarios. The ongoing development of such a model is reported in the paper.

1.2 Delimitations, structure and methodology

The requirement profile of the model was developed iteratively in a dialogue between researchers from the traditions of futures studies, city planning and energy technology. In parallel we used ”top-down” and ”bottom-up” approaches. The former is the seminar-based exploration of the model's *usage situation* [Svane et al. 2011b], with the model as a black box. The latter is based on our analysis of established ways of modelling energy systems [Jonsson et al. 2011].

The paper's focus is on the model's user interface rather than on its internal properties. Therefore, section 3's results of the top down approach present the model's requirements profile as defined by its usage situation. There, we also outline its conceptual structure and where we stand in model development as results of the bottom-up approach. Section 2 has a background of the district renewal and our scenario. Furthermore, the project's research strategy is outlined, we discuss the computerised modelling of energy systems, and give theory on governance and negotiating sustainabilities. Section 4 has preliminary conclusions.

2 BACKGROUND

2.1 On the SitCit project

Our ongoing research – SitCit for short – is a five-year cross-disciplinary project. The full title is "Situations of Opportunity in the Growth and Change of three Stockholm City Districts – everyday life, built environment and transport explored as Energy Usage Systems and Transformative Network Governance". It explores city transformation guided by a vision of a low carbon, low energy society in 2060. ETH researchers operationalised this as the “2 kW Society”. In it, each person on average emits 1 ton CO_2 and uses 2 kW [Jochem 2004]. In Sweden, this calls for a reduction by 60 % for the 2kW-target, and by a factor five for CO_2 [SCB].

SitCit scenarios have a time horizon of 15-20 years, and explore potential contributions to the 2 kW vision. Each scenario has a counterfactual “What if…” question indicating a transformative opportunity, as applied to a place and its factual problems such as the need for renewal of Rinkeby-Kista. Transformation is to be plausible but not the most probable future development. To explore the opportunities of such a situation we ask in parallel *What* to change and *by Whom*, *How much* change contributes towards a 2 kW Society and *How* transformation enfolds over time. In this paper, the focus is on the evaluative *How much* question.

2.2 On the Rinkeby-Kista scenario

The Stockholm City district of Rinkeby-Kista is located 5-10 km to the northwest of Stockholm, and built in the 1960s and 1970s. Around 45 000 residents live there. On the average, they have lower incomes and unemployment is higher than the Stockholm average. The share of immigrants is high. Criminality and juvenile delinquency are also mentioned as problems [USK 2012]. The area is due for renewal for technical reasons: The service life of façades, roofs and plumbing is almost over. There are also plans to address the socio-economic problems in an integrated, long-term manner. To this end, an organisation with representatives of all major actors, the “Järva Boost”, was formed [Järvalyftet 2012]. It is an extensive, network type organization with ambitious aims.

Our futures studies scenario was built to explore ways of going “Beyond Järva Boost” [Hadipoor & Svane 2012]. It builds on the characteristics of the area and its users as well as the renewal plans, but merges these with counterfactual measures and actors. The scenario is qualitative, combining journalistic narrative, descriptive text and tables. The first narrates the transformation as seen from the future. The descriptive text lists measures under headings such as Built premises, Energy efficiency, Closed loop strategies, Social aspects and Public space. “What-Who” tables indicate the relations between measures and actors: Façade insulation is the manager’s measure, reduced use of hot water relates to residents, fossil-free district heating to the energy provider etc.

These texts are the inputs to modelling. Thus, quantitative data on the building stock, present energy use, estimated reductions of energy use etc. must be supplied by the model builder. Furthermore, the same scenario can have a range of outcomes in terms of reduced energy use and emissions. This leads to an important distinction: We have one model of one scenario, but it enables us to simulate cases of negotiating sustainabilities that have contrasting outcomes.

2.3 On governance, actor networks and scenarios

In part, our scenario of the renewal of Rinkeby-Kista goes beyond present planning practice. One example is the shift towards governance [Hajer & Wagenaar, 2003] – from planning’s traditional exercise of public authority to the new role of facilitator. This role requires the planner to identify opportunities for change far in the future, articulate possible and necessary directions for sustainable change and mobilize the change agents [Wangel et al. 2012]. This use of informal organisations is the perspective of network governance [Jessop 1998; Bogason 2000]. In it, the planner takes the role of meta-governor [Sørensen 2006; Sehested 2009].

Scenario building through backcasting is a futures studies approach that could be a fruitful addition to planning for urban sustainable development. A backcasting scenario is a goal-fulfilling image of the future [Dreborg 1996; Robinson 1990;

Quist & Vergracht 2006]. Furthermore, planning for urban sustainable development calls for scenarios to include actors [Robinson 1990; Höjer & Mattson 2000; Green & Vergracht 2002; Åkerman & Höjer 2006; Andersson et al. 2008]. Thus, the type of scenario that we want to evaluate in terms of energy efficiency and CO_2 reductions is developed through backcasting and includes social structures and agency.

2.4 On computerised modelling of energy systems

Energy systems analysis is a branch of systems analysis. Churchman [1968] singles out five analytic perspectives, namely the system's objective, environment, resources, components and management. Thus, the system is defined through its parts as well as by whose is the system. Systems analysis distinguishes between hard and soft approaches. The former is about optimisation or control, the latter strives for learning and understanding [Pahl-Wostl 2007]. Additionally, the soft approach is used for ill-defined problems, and includes cultural considerations and qualitative data [Checkland 1999]. In the research tradition of energy analysis, a systems approach is common, and hard approaches dominate. In analysis, the system is represented by a model, a simplified representation with the purpose of understanding or of informing decision makers.

Computerised modelling of a scenario such as that of Rinkeby-Kista as an energy system, calls for both hard and soft approaches. Quantification is a hard feature, while other elements are soft: The model does not optimise energy use, but explores reduction potentials; modelling is part of a learning process, involving also external experts. Furthermore, the actors' perspective is at the fore; sub-systems are defined through asking who can change what part of the system.

3 RESULTS

3.1 On the usage situation of the model

Our "top-down" results concerning the model interface begin with an observation: To be useful, any assessment tool needs to form a coherent evaluation situation together with the scenario content. Two questions ensue:

Which is the assumed assessment situation?
A general description of an assessment situation starts with its purpose; it includes who is the assessor, how often is the tool used, how labour and data intensive is its use, who wants its results etc. Checklists and qualitative aids such as BREEAM Community [BREEAM 2012] or the Aalborg Commitment [Aalborg 2012] can be used by the scenario builder already during a scenario's formative stage. This usage situation has the purpose of including a comprehensive set of urban sustainable development issues. Simulations with a model are powerful aids to optimize or maximize the outcome of an energy efficiency scenario in the later stages of development. However, we are developing a model for ex post evaluation. In the long term, the evaluator could be a planner. For the moment however, we envisage researchers as model users, and evaluation has the purpose of exploring the scenario's potential contributions towards the 2 kW Society.

What common properties have the scenarios that we want to assess?
The Rinkeby-Kista scenario is not representative of futures studies' backcasting scenarios on urban sustainable development, as indicated in a literature review [Wangel 2011]. Ours has an explicit, balanced representation of agents and objects of change, most similar scenarios have not. However, agency can be derived from the scenario narrative if you know the scenario's planning context [ibid.]. What, then, does such a scenario's contain? It illustrates the outcome of a planning process, in a high-income country, as based on a real city or a city district, and looks twenty to fifty years ahead. Furthermore, it explores alternative

developments – planning's field of options. Finally, it is normative, illustrating how to address the aims of urban sustainable development – whether the aims are explicit as in a true backcasting scenario, or understood. Excluded are prognosis scenarios that illustrate what will probably happen, and detail regulatory plans that directly guide what will happen. Based on this we outlined the following "ideal type" usage situation:

It is early in the actors' process of negotiating energy efficiency aims when planning for the renewal of a city district such as Rinkeby-Kista. A scenario such as "Beyond Järva Boost" gives input. Around the table are housing managers, their consultants and contractors, and the energy provider. A City planner is chairing the session; colleagues from its development and environmental administration also participate. Furthermore, the residents and local associations are represented. The planner invites the participants to a series of role games. In each of these, every participant represents her/his own organisation, but with contrasting attitudes to the game of negotiating sustinabilities. The outcome of each negotiation game is simulated in real time in the model. Model handling proper is by a specialist.

A first simulation uses integrative or win-win negotiation [Raiffa 1982]. The context is presented in such a way that their organization will benefit only if all negotiators come to agreement. Thus they are to be collaborative and accommodating, and to focus on the aims of the 2 kW vision as a long-term necessity. Each actor suggests measures that are negotiated into a consistent whole: "…we renew 30 per cent of our stock to passive standard…", "…we adapt our system to accept solar panels…", "…we launch a campaign for using less hot water…" etc. The whole forms the input to a simulation in the model. In distributive or win-lose bargaining [ibid.], the actors are asked to instead negotiate with their own organisation first in mind: "…we do not compromise profit to benefit the whole…". The outcomes of this negotiation form input for a second simulation. The two contrasting outcomes are then discussed by the participants, to give input to the researchers' scenario evaluation.

3.2 On the model of Energy Usage Systems

The "bottom-up" findings concerning model properties are based on our previous research on energy systems with a soft systems' approach [Jonsson et al. 2011]. It resulted in a conceptual model with the purpose of identifying the local actors' energy efficiency potentials.

Energy systems analysis generally focuses on energy supply and distribution [Steinberger et al. 2009; Groscurth et al. 1995]. Human activities and the demand for services requiring energy are seldom inside the system boundary. Why? Energy production and distribution are centralized to few energy companies, while the user side comprises millions of end-users and many diverse technologies [Jochem 2000]. The heterogeneity of the user side complicates analysis.

However, we argue that a view of the energy system that begins with the user side, will identify greater potentials for increased energy efficiency [Jonsson et al. 2011]. One example is Lovins' [1996] 'tunnelling through the cost barrier'. If the efficiency of all end-use technologies is seen as a whole, the efficiency potential becomes larger than when looking at each component separately. This view also allows for exploring the potential of institutional changes, such as hourly electricity pricing based on momentary demand. In all, the end-use approach opens up perspectives that are hard to capture in conventional models of the energy system.

The end-use model has as its core the *human activities system* as driver of energy use. Applying an "upstream" logic, *services* are defined as the utilities that enable activities. The next items upstream are the energy usage systems that provide services, demanding energy from the distribution and supply systems. To give an example, the activity "preparing food" calls for the service "heating foodstuff", as provided by the energy usage system "stove", which gets electricity from the grid. See Figure 1.

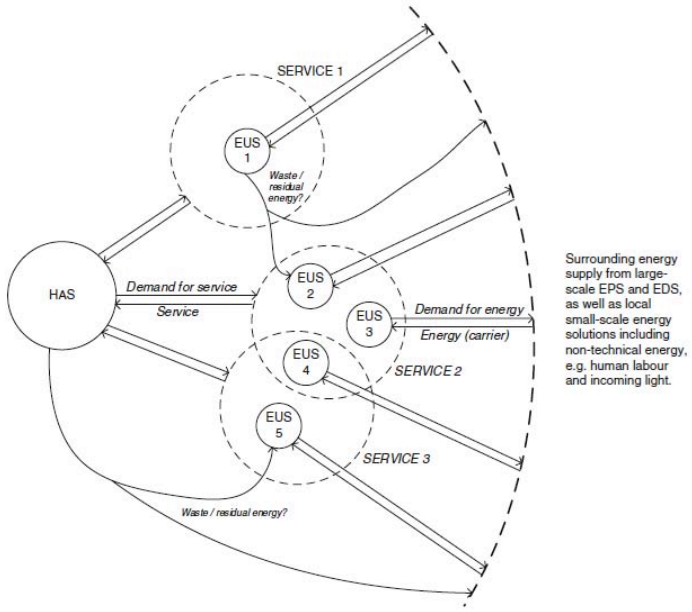

Figure 1. The conceptual model of the energy system has a series of energy usage systems (EUS), such as stove, radiator or TV set. These provide services to the human activities system, (HAS). In their turn the EUS are supplied with energy. Source: Jonsson et al. 2011.

3.3 On the modelling process

As mentioned, pre-designed energy software was unsuitable in the SitCit project, since the research questions go beyond standard approaches. Instead, we use Stella©, a software designed to explore and learn, and having a graphic interface. For the ongoing modelling of Rinkeby-Kista (and similar scenarios), a process consisting of five phases is used [Kliatsko 2012].

The first phase results in a conceptual model of the system, as previously outlined. Development started with the model purpose. Then we identified the system components, their interconnections and the system environment. The model has 5-10 Human Activities Systems, categorised to include all activities of a day. They connect to the Energy Usage Systems providing services. Modelling used Casual Loop Diagrams to negotiate the conceptual model in focus groups [Wikipedia 2012, isee 2012). The second phase produced a qualitative model specific for the scenario at hand – its place and actors, the intended process of change etc. Some aspects of the full conceptual model were excluded; for instance commuting and working are not objects of change in the Rinkeby-Kista scenario and therefore not modelled.

In the third step, each subsystem is modelled using Stella© software. The model interface enables the "staging" of the actors' negotiations: The building manager's controller influences the climate shell properties, the residents control their energy use for personal hygiene, the energy provider the primary energy supply etc. Model inputs are technical (heat retrieval), institutional (hot water billing) or socio-cultural (information to residents). Outputs are energy use in kW/person and CO_2 emissions. The fourth step is model calibration. After that, it can be used to evaluate the outcomes of different combinations of decisions taken in role games of negotiating sustainabilities, as previously outlined.

4 CONCLUSIONS AND RECOMMENDATIONS

This paper gave insight into the ongoing development of a computerised model for assessing futures studies scenarios such as that of Rinkeby-Kista. Initially, we asked what properties such a model needs in order to enable:

- the modelling of a scenario exploring the renewal of a city district, transforming its structures and indirectly influencing its users' everyday activities, and

- real-time simulations of the outcomes of negotiating sustainabilities' role games.

We also argued that to justify the effort of in-house modelling, we should explore which types of scenarios and in what usage situations the model can be used. At the moment, model development is in the middle of a merge between the top-down and bottom-up approaches selected as methodology. Therefore, the paper gives tentative and partial conclusions.

The top-down approach generated a narrative of an "ideal type" usage situation, in which the model in real-time simulates the outcomes of a series of role games of negotiating sustainabilities. The bottom-up approach resulted in a generic model of the energy system with the Human Activities System as core. Energy Usage Systems surround the core, providing services. Distribution and supply are upstream, in the system surroundings. The first two modelling phases are finished, the third and fourth ongoing. In the second phase, the human activities and the energy usage systems were categorised, based on the content of a scenario such as Rinkeby-Kista. Through use of Stella©, the model is now made quantitative, and gets an interface to fit its usage situation. Master students' enacting a role game gives input. Calibration follows next. Validation in role game based simulations with practitioners end development, and bridge to a real usage situation.

The distinction between Human Activities System and Energy Usage Systems, respectively, operationalises our aim of separating structure and agency in the model. Similarly, DPSIR Responses are the scenario's physical and institutional objects of change, modelled as Energy Usage Systems. The DPSIR Drivers are the activities in the Human Activities System.

Thus, we are developing a model to simulate the outcomes of role games when negotiating sustainabilities; remains to see how wide a selection of scenarios that in fact can be evaluated by the model. At any rate, the conceptual and qualitative models apply beyond the Rinkeby-Kista scenario. It remains also to see if such scenarios and simulations via the model can be introduced into planning practice.

Detail regulatory plans are examples of traditional planning as an exercise of public authority. Tomorrow's planning, with strong elements of governance and negotiating sustainabilities, is an interplay of interests with formal and informal power relations. The element of governance grows when negotiating the challenges of urban sustainable development. Scenarios, modelling and simulations could support. However, unlike detail regulatory plans, the simulated outcomes of a role game will influence planning only in informal ways, through its persuasive powers.

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