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The building process of single-family houses and the embeddedness (or disembeddedness) of energy

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ABSTRACT

People building their own houses have, at least theoretically, substantial autonomy when choosing, for example, a heating system and windows. In this article, focus is on the process of building new single-family houses and how energy efficiency and energy-efficient technology are incorporated into the building process. The conclusions emphasize energy as only one factor in housing purchase decisions. It is a big challenge to make low-energy building important to consumers. Consumer preferences for new products are unlikely to fully develop unless individuals have the opportunity to interact with them. It is difficult for consumers to know what to ask for if they lack experience of energy-efficient technologies. In the studied cases, the building codes and established standards became extremely decisive for how energy issues were included in the process. There is a need to change the design of incentives so as to make the least energy-efficient choice the most expensive. The most

energy-efficient solution should be standard, and if the buyer wants to depart from that standard and build using less energy-efficient construction, then that should cost more.

Keywords: Building process, Household, Consumers

Introduction

In the EU, the housing sector accounts for approximately 40% of total energy demand, while in Sweden it accounts for around one-third of Sweden's total energy use. Of this, the operational phase accounts for approximately 85% of a building's total energy use (Lindén, 2007). Energy efficiency ambitions in the housing sector are supported by extensive and ambitious policy making. The European Union has, for example, the 20-20-20 goals and the European Energy End-Use Efficiency and Energy Services Directive (ESD; EC Directive 2006/32/EC), according to which each member state must formulate and design a National Energy Efficiency Action Plan (NEEAP). Sweden, often cited as a role model (and used here as an example), has even more ambitious goals than the EU goals, for example, to eliminate all fossil fuel use in its housing sector and to halve its energy consumption by 2020 and 2050, respectively (Government Bill 2008/2009:162; Government Offices of Sweden, 2013).

The goals are ambitious and the time frame for implementation is short. A house is often part of the housing stock for decades and by making initial energy-efficient choices in the building phase, the long-term environmental impact can be reduced. How houses will be built today will shape energy consumption for years to come. But how central are energy-related choices in the building process? Or to be more precise, why is not the best available energy-efficient technology implemented when new houses are built? Understanding how decisions related to

energy efficiency are made in the building processes is vital if we are to understand why the best available technology is not used when there is the chance.

The building process of new single-family houses in two municipalities in Sweden has been analyzed: 20 new houses were built in municipality A and 80 new houses in municipality B. Both areas were “normal” in that they were not niche promoted as green areas, green villages, eco-villages, or the like. In both districts, the company Myresjöhus was the building contractor, and the families were free to choose the design of the houses, what heating system to install, the thickness of insulation, the energy standard of the appliances, etc. In both cases, all families chose a standard rather than a low-energy house, which was available as an option. None of the families in these two areas made partly energy-efficient choices, i.e., that went beyond the standard, such as thicker insulation or low U-value windows. The choices the families made were in many aspects identical, which is very interesting. How can this be explained?

Families building their own houses have, at least theoretically, substantial autonomy when choosing, for example, the heating system, wall thickness, and windows, and when making other long-term decisions. In the process of building new houses, families decide on a number of energy-related factors, all of which will significantly influence their energy consumption (and energy expenses) for a substantial time to come. However, the homeowners’ choices may be limited and restricted by municipal policy, building contractor guidelines, and district heating company strategies, making these considerations important to include when discussing homeowners’ energy-related choices in the building process. Rules, building codes, and other factors that influence energy efficiency in conjunction with the building process are also relevant. How these actors, standards, and policies are integrated in the

homeowners' decision-making process and how these affect the families' opportunities to influence energy efficiency in their houses will be included in the analysis.

The focus in the analysis will be on homeowners, building contractors, local district heating companies, and the local authorities. The following two questions have guided the study:

- How did municipal policy and building contractors' energy and building standards affect homeowners' decision-making processes when building new homes?
- How did homeowners explain why they did not choose the most energy-efficient technology when designing their houses?

The context: the local building process in Sweden

Swedish energy policy directed toward single-family houses impinges on various actors, such as the self-governing municipalities, house builders, and house purchasers. According to the Swedish constitution, municipalities have exclusive planning power – a crucial prerequisite for their ability to formulate policy and exert influence. In the energy area, Swedish municipalities function as public authorities, social planners, and social informants. They also draw up local planning documents and can, for example, plan the building density in a way that favors district heating. It is also the municipalities that issue building permits (Palm, 2006).

Many municipalities in Sweden own a municipal district heating company that plans and operates various energy activities. Municipally owned district heating companies usually both produce and distribute electricity and district heating. They are subject to guidelines and regulations drawn up by municipal decision-making bodies, and municipalities steer these

companies by retaining all or at least most of their shares and exerting ownership control (Palm, 2006).

The Swedish Board of Housing, Building and Planning is the administrative authority responsible for construction and the built environment. This authority draws up mandatory provisions and general recommendations on the construction of private and public buildings. The Board's building regulations apply when a building is constructed or extended, and the municipal building committee is the controlling authority. In Sweden, climatic conditions vary significantly between climate zones. To formulate rules aligned with these differences, three regional levels—the north, central, and south zones—divide the country with regard to energy use requirements. Table 1 shows the maximum permitted energy use in the three climate zones.

Table 1

Specific energy use (kWh/m²/year) in non-electrically heated buildings in Sweden's three climate zones.

Climate zone	I (northern Sweden)	II (central Sweden)	III (southern Sweden)
Building's specific energy use [kWh/m ² A _{temp} /year]	150	130	110

According to energy use statistics, for the average Swedish dwelling of 147 m², the total energy use for heating and hot water is roughly 18,600 kWh/year or 126.5 kWh/m², while household electricity consumption totals about 6300 kWh/year (SEA, 2011). Heat pumps are common in Sweden and 46% of single-family houses were heated completely or partially with heat pumps. District heating was the main heat source for 12% of the single-family houses (SEA, 2011).

Method and materials

To address the questions focused on here, in-depth interviews were used as the main research method. Municipal politicians (i.e., the heads of the community planning boards) in the two studied Swedish municipalities, both situated in northern Sweden, were interviewed.

Interviews were also made with the building contractor, Myresjöhus, that marketed the houses in the two studied areas and homeowners who had built a new house within the last three years.

Myresjöhus is a major actor in the Swedish housing sector; in an initial phase of the study, Myresjöhus representatives at two local building offices were contacted and invited to participate in the study. The two municipalities were chosen based on their different sizes and structures and on fact that Myresjöhus was building or had recently built residential neighborhoods in them during the study period. Another prerequisite was that the residential areas were not supposed to have been marketed as green areas, green villages, eco-villages, etc.

While municipality A has a population of roughly 14,000, municipality B has about 110,000 inhabitants. Furthermore, municipality B is a majority shareholder in its local district heating company, while municipality A owns only 1.6% of the shares of its district heating company. Consequently, municipality B is better able to influence the district heating company's policy regarding, for example, the distribution and expansion of district heating.

Through the local Myresjöhus offices, households in the two areas were contacted and invited to participate in the study. A total of 17 households agreed to participate, eight from municipality A and nine from municipality B. All of the interviews were semi-structured,

recorded with an MP3 player, and then transcribed. The homeowners' identities were anonymized; to safeguard this anonymity, the municipalities will be referred to as municipality A and municipality B. The building contractor's representatives' identities are also anonymized; they are described in relation to the municipality in which they operate.

The interviewed homeowners have all moved into their present dwellings and were 30–65 years old at the time of the interview. Some have university degrees and the household income is EUR 40,000–85,000 per year. The families consist of two to six members.

In municipality B, district heating, in some cases combined with a wood stove, was the dominant mode of heating, while most households in municipality A had installed heat pumps, sometimes in combination with a wood stove.

Energy choices made in a social context

Economic factors are important when analyzing technology diffusion. At the same time, it is important not to overemphasize the economic incentives, but also to consider cultural, organizational, aesthetic, and symbolic factors that are important when people choose technological solutions and appliances for their homes. It is important to understand the choices made when building houses in their context. As Weber (1997) explains, “energy consumption is the last part of a long chain of decisions and actions. Therefore, it is appropriate to discuss energy consumption within its social context” (Weber, 1997, p. 835). In science and technology studies (STS), the interdependence of technology and society as well as individuals' ability to shape the technologies surrounding them have long been recognized (Bijker and Pinch, 1987; Callon, 1987). The idea is to recognize the importance of both

context (here, available technologies and provision systems) and action (here, the energy-related choices made when building new houses). There is an interdependence between technology and society, and as well as technology shaping peoples' everyday lives, individuals also have the ability to shape their environments, including the technologies surrounding them (Hughes, 1983).

Even though individuals have the opportunity to shape their surroundings, the momentum in the building sector is well documented. Momentum is high in the housing sector because of the durability of housing products and the considerable capital cost of production (Crabtree and Hes, 2009; Glad, 2012). The existence of momentum in the building sector also means that innovative new products such as low-energy housing are more costly and entail high risk, because such solutions do not fit easily within the existing sociotechnical system (Lovell, 2005). Another factor affecting the low level of new product innovation is the lack of consumer experience of, for example, low-energy housing. Households do not know that other solutions exist because they have no experience of living in a low-energy house and simply do not know what to ask for (Palm, 2011). This also contributes to the slow market expansion of energy-efficient technology.

Studies demonstrate that residential housing contains significant unrealized energy-efficiency savings potential, despite the fact that realizing it would be profitable. Hence, there is an “efficiency gap” due to lack of knowledge, time, and interest (Backlund et al., 2012; SOU 2008:110). When homeowners buy a house or build a new one, energy-related choices may not always be of central interest, other aspects such as price and location being more important. Deciding what energy-related issues to consider, such as choice of heating system, appliances, etc., is a process whereby the household: a) collects information about available

solutions, b) investigates their pros and cons, and c) makes and implements the decision (Rogers, 2003). There are many energy-related alternatives on the market, and estimating the most economically or environmentally beneficial one is not easy. Some important issues that the households have to consider are: energy costs, the heating system's effect on the value of the house, local and global environmental aspects and the value of a "clean" system or technology, and fees and tariffs related to the inspection and maintenance of a system.

Adding to this, households must also decide on a number of other, non-energy-related issues in the building process. Drawing on just a few examples from the nine-page option list from Myresjöhus, the customer must choose both exterior features and fittings of the house—foundation, wall panels, roofing, porch, balconies, windows, doors, and carport (and color of the same)—as well as interior features and fittings. Decisions on the latter concern, for example, wallpapers, fireplace design, stairs, indoor fittings (e.g., type and color of door handles and frames), flooring material, and bathroom fixtures (e.g., tiles, toilet seat, basin, and cabinets).

From a household perspective, it can also be important to make an economically rational choice of heating system that can be justified to friends and neighbors; when the choice has been made and the technology has been installed, it is also vital that the decision be confirmed and accepted by others (Henning, 2000; Palm and Tengvard, 2011). However, the assumption that households make such rational choices is difficult to empirically verify; for example, according to Mårtensson and Frederiksen (2005), although electric boilers are usually classified as the most costly alternative when both up-front costs and operating cost are considered, they are the most common heating system in smaller houses in Sweden. Residents' attitudes to technologies also affect their decisions, and they may prefer less-

efficient heating systems such as gas fires (Bell and Lowe, 2000). This indicates that what is deemed rational from a technical or economic perspective may not necessarily be rational to the individual user (see also Bartiaux, 2008; Palm and Tengvard, 2011).

In addition, although individuals might try to behave rationally, they are not always aware of all the alternatives on the market, or may be unable to collect and process the information (March, 1994), and thus focus on a smaller number of alternatives and consequences while ignoring others. The goal is often to achieve a result that is satisfactory rather than calculating the expected results and risks and then making the most rational and optimal choice (March, 1994).

An STS approach will be used when analyzing the process of building single-family houses and seeking to understand the energy-related choices the families made in this process. It is assumed that the purchase decision is not made in isolation but is embedded in a complex relationship between demand, price, routines, standards, norms, values, pragmatism, etc. In the analysis, the focus will be on the following:

Technology provision	Market transactions	Sociotechnical interaction
Local planning	Information search	Actor–network
Marketing and installation of technical equipment	Bargaining	Communication
	Decision costs	Experience of low-energy technology
		Feedback

Results: the actors' view of energy in the building process

Below I will discuss how the municipal authorities, building contractors, and households reasoned about the choice of heating system, energy-efficiency measures, and their own and others' responsibility for constructing an energy-efficient building.

The choice of heating system

Municipality B owns the majority of the shares in its local district heating company, and the local authority and the district heating company collaborate closely. In this municipality, all homeowners chose to connect to the district heating grid. When I wondered how this could be explained, the interviewed politician simply said: "They had the option to choose other alternatives, too, but we made them an offer they could not refuse." Municipality B plans to densify the city to reduce the cost of extending the district heating grid. The view articulated by the heating company representative correlated with that of the municipal politician.

In municipality A, the link to the local district heating company is not quite as clear, which can be explained by the fact that the municipality has only a small ownership stake in it. Here the strategy was to give the homeowners the *opportunity* to connect to the grid and to inform them of the pros and cons of doing so, and then leave it to them to decide. This way, the municipality can avoid responsibility for "forcing" citizens into dependence on the district heating company and its tariffs. "We don't want to force the households to connect to the district heating system – that would be too bossy and would intrude on peoples' lives," explained the head of the community planning board in municipality A. The district heating company representative said that the company did not offer district heating to the studied area

in municipality A because there were not enough buildings there to make it profitable.

According to the detailed development plan of the area, more houses would be built in the future, but the company wanted to wait to be sure the plan would be realized before making any investments.

There is a major difference between the two municipalities' energy policies: whereas municipality B actively encourages households to choose district heating, municipality A puts less effort into shaping households' choice of heating system.

In municipality A, where there is no district heating in the studied area, the building contractor Myresjöhus recommended that customers install air-source heat pumps combined with wood stoves. According to the representative, this was the most energy-efficient and economically prudent choice, but he added that he "willingly discusses the cost and payback time of other alternatives." Myresjöhus initially negotiated with the local energy company to provide district heating in the area but, due to the small number of residents, the company was unwilling to expand the grid. Instead, Myresjöhus cooperates primarily with other system distributors and subcontractors. When asked about his view of district heating, the Myresjöhus representative replied:

Sure, district heating is great, but we are already seeing signs that prices are going up in areas connected to the grid, so there are not only advantages ... If you have chosen district heating, it is rather expensive to convert.

The situation is the opposite in municipality B, where there is a strong tradition in favor of district heating. When building new residential areas here, Myresjöhus generally signs contracts with the municipal district heating company to provide the homeowners with the option of connecting to the grid. According to the Myresjöhus representative, the households are informed of alternative heating options when considering buying a house from Myresjöhus. However, only those moving into detached houses can freely choose the heating system; those purchasing terraced houses have only district heating as an option.

This is how the interviewed Myresjöhus salesperson in municipality B commented on the policy of promoting district heating as the default alternative:

We don't want to be too bossy, but at the same time, in a way it depends on your assumptions. We are sort of going for district heating here—in this city we have district heating and it's all good. It's trouble free and we know it is the cheapest option ... Also, a lot of people are not aware—they don't care how it works and they don't want to find out either. So, it's a matter of finding easy systems ... and then, district heating is a good option.

The homeowners uniformly told us that they were essentially forced to choose the heating system that the house vendor offered by default: “We had to go with district heating—it was the only option discussed,” a household in municipality B said (HO1). Those who had looked at alternatives such as ground-source or lake heat pumps had to raise the issue and explore the possibility of these options themselves. According to one homeowner, they would still have to pay the connection fee for district heating in the end, so they did not press the issue.

In addition to the lack of influence when choosing the heating system, one of the interviewed families especially stressed the small possibility of influencing the building process itself. This was mainly because they knew nothing about the materials used or how they had been transported; they would have liked more information about many things:

Everything, everything, everything! I would have liked to have been more active in my choices, as I think these things are important. (HO8)

Measures to improve energy efficiency

Both municipalities had decided on a policy stating that homeowners should help reduce energy use in the building stock. However, when the municipal representatives were asked how they had pursued this goal and what information they gave to, for example, the homeowners we studied, neither could cite any measures. Neither of the municipalities had, for example, provided any energy-efficiency advice in connection with the building permit process, a mandatory process in which the homeowners have contact with the municipality. The municipalities had different explanations for this missed opportunity. Municipality A said that they had decided to focus on their own building stock to provide a good example for citizens. Municipality B had created a network of local stakeholders influential in housing sector energy consumption; the homeowners (or tenants) and their interest organizations were not included because

It is the actors in the first phase of the building process that have the real influence. (Politician, municipality B)

According to Myresjöhus, the most important factor promoting improved energy efficiency in dwellings is the overall construction quality of the foundation, walls, and roof and whether the house is well insulated. Myresjöhus markets one type of wall as standard, and the customers are directed to this type. According to the Myresjöhus representative in municipality B, thicker walls are not asked for by customers:

I think people trust that the houses are well constructed in terms of energy—and they are. What they are interested in is price, layout, kitchen doors, and bathroom. Those kinds of things are what they ask about.

However, more energy-efficient windows can be bought at extra cost and customers are informed of this before making the purchase. However, the interviewed Myresjöhus representatives are unsure whether these windows are actively marketed to the customers: as in the case of thicker, more insulated walls, there is simply not much interest in such windows among the customers. The customers have no or very little knowledge of these issues, for example, about how much extra energy large windows consume. The Myresjöhus representative in municipality A said:

Mainly, they want to know the cost of building the house, whereas questions about saving energy and the environment are maybe number ten or twelve on the list.

The homeowners stated that they had little impact on the choice of heating system, insulation, windows, appliances, and so on. The main reason the homeowners gave for not exerting

greater influence on the building process was time: their time was limited and there were many decisions to make and many things to arrange. Some households stated that they had just a few weeks to make many decisions, ranging from choice of wallpaper to heating system. Anything they wanted built differently from the standard specifications had to be decided on very quickly:

It happened so fast, too. They rang in the morning and wanted a decision the same day. We had to choose tile. And everything was like that some days. They were very quick choices, so we could not look around and, for example, influence the choice of tradesmen ... It was very frustrating.
(HO8)

In general, the homeowners felt that it was difficult to influence the choice of appliances installed in their homes. Among other matters, one homeowner noted that the dishwasher did not have a satisfactory short program, so instead she uses the more energy-wasting standard program (HO6). Other homeowners meant they had little ability to adjust the thermostat to lower the temperature and reduce the energy consumption. Furthermore, the homeowners claimed they did not have the opportunity to choose thicker walls than the standard. Some, however, said they were given the opportunity to choose windows of a different u-value but did not regard it as necessary to make any changes to the standard equipment and fittings.

This was common among the interviewed homeowners: most did not actively explore available alternatives to the standard equipment and fittings in their new houses. The households that did not look for alternatives said that they would have liked more information, for example, on alternative heating systems and energy-efficient solutions. In

retrospect, they think that they would have made more active choices and not just installed the offered standard equipment had they known more about these matters. At the same time, the limited choices were sometimes perceived as positive:

There were so incredibly many choices to make, so we thought it was easiest to choose, for example, district heating. There were so many other choices to make, that it felt almost too much to have to choose the heating system as well. (HO4)

Someone else's responsibility

All the interviewees were asked about their responsibility to ensure that detached houses were built in a more energy-efficient way. In a rather classic way, none of the informants acknowledged having the responsibility, but instead pointed to other parties.

The municipalities said that they had a limited ability to influence the energy outcome of a building. They could mainly inform purchasers of the possible options and available technology that contribute to energy efficiency. It was regulations and laws as well as the professional actors in the building process that had the real influence.

The Myresjöhus representatives also emphasized the importance of building codes and regulations. They claimed that customers' demands were important and could have a major influence on how energy efficient their houses would be.

The homeowners generally believed that Myresjöhus had the major responsibility for making the houses energy efficient—“Myresjöhus does, of course, build energy-efficient buildings” (HO 11)—so the households themselves felt they did not need to do much when it came to the building envelope.

Yes, it feels like they really have more responsibility than I do, because I, as an individual, have so little knowledge of the available options, the possibilities. So the construction industry should have the greatest responsibility. (HO4)

The homeowners had great trust that their houses met a certain standard in terms of window u-value, wall thickness (i.e., r-value), and general energy efficiency. This is how one homeowner described the building contractor Myresjöhus: “They are generally very environmentally aware—it feels as if they are trying to hold down energy costs” (HO6). She trusted their standard specifications and that they were building compact, energy-efficient houses. Therefore, she felt justified in being fairly passive in her decision making, a view she shared with most of the homeowners (HO6).

One homeowner said that he, as a consumer, had few possibilities to exert influence, so great responsibility was borne by those who build the houses and do have a voice: “Because I cannot do that as a buyer—I buy a turn-key house and hope it is good” (HO2). He came back to the point that the individual already has a great deal to think about in connection with house buying and building; energy efficiency is just one more bothersome issue to keep track of. Therefore, responsibility for energy efficiency should lie mainly on house builders and policy makers.

Conclusions: time for a change in outlook

The housing market has significant inertia and low rates of innovation, due to the considerable capital cost of production and the durability of the housing product. Alternative solutions do not fit easily within the existing sociotechnical system, which became obvious in the cases when one municipality argued for district heating that fit their existing sociotechnical structure, while the other argued for heat pumps because that technology fit more easily into existing networks and arrangements.

Technical knowledge, regulations, and production methods are all aligned toward building dwellings in a particular way. New standards and ways of doing things entail monetary costs, such as time spent changing procedures, habits, and norms. That being the case, the needed change is unlikely to happen. As shown above, the need to improve energy efficiency is not deemed a critical systemic issue that demands a solution, which is another reason why energy efficiency is not promoted.

Some research notes the higher cost of building lower-energy housing and that consumers are unwilling to pay this. In our cases, energy-efficient solutions were more expensive, but that was not the main reason why the households did not choose them. The increased cost was not an issue in these cases, because energy-efficient solutions were not even presented as an option to the households. They did not need to make an active choice between, for example, higher investment cost but lower energy cost due to reduced energy consumption in the house, and lower investment cost but higher energy cost. Factors other than cost and price were more important in the decision-making process.

As mentioned at the beginning, energy issues will always be just one factor in housing purchase decisions, but in the studied case it is questionable whether it was a factor at all. It is a major challenge to make low-energy construction important to consumers. Consumer preferences for new, more energy-efficient housing products are unlikely to fully develop unless individuals have the opportunity to interact with different types of housing. This is particularly the case for low-energy housing technologies, such as thermal wall insulation or heat-recovery ventilation systems, that are invisible. In addition, it is difficult for consumers to know what to ask for if they lack knowledge and experience of such technologies.

In these cases, the building codes and established standards were extremely decisive for how energy issues were included in the process. The contracting company and the buyers followed the guidelines and, from this perspective, cannot be criticized for how they integrated energy into the process. However, there is a need to start taking building codes and standards more seriously. It is also important to change the design of incentives and make the least energy-efficient choice the most expensive, and challenge today's system in which it is more expensive, from a policy perspective, to make a very much needed energy-efficient choice. The standard or default should be the most energy-efficient solution; if the buyers want to depart from that standard and build using less energy-efficient construction, then they should need to pay extra for that.

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