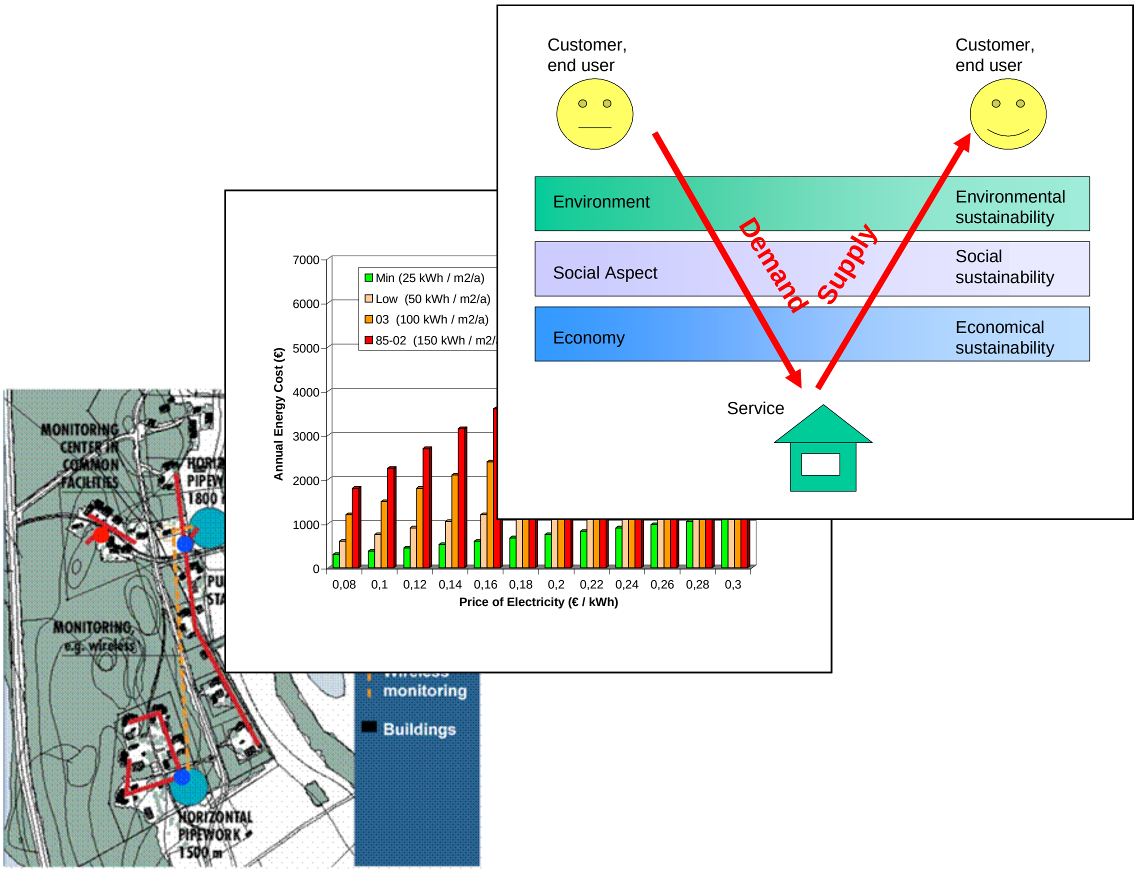

Minna Halme, Jyri Nieminen, Esa Nykänen, Leena Sarvaranta & Antti Savonen

Business from Sustainability

Drivers for Energy Efficient Housing

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Drivers for Energy Efficient Housing

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Abstract

Why is the market interest in energy efficient houses still low? Is it because consumers do not want to pay a higher initial investment cost? Are consumers interested or aware of energy related issues? Are the constructors unwilling to push these products to the market in a situation where price seems to be the only source of competitive advantage?

In the last 15–20 years, a number of projects have been carried out aiming at energy-efficient and environmentally friendly housing. There is a wide range of technologies and concepts that have been tested in monitoring projects. Technological possibilities to reduce a building's energy consumption have been available for a long time. Also, the costs of energy efficiency have been proved to be almost negligible. Despite the existing vast amount of information, no clear market change has happened.

The scope of a low-energy building is to achieve comfortable, healthy and safe indoor climate. The construction is based on simple and well performing materials, structures and building services systems that fulfil the requirements set for the building. Energy efficient housing would offer many individual level benefits, and in order to assess them one should have a long-term perspective. As heating accounts for a majority of the life cycle costs of a house, energy efficiency means substantial cost savings. However, up to now most homebuilders are not focused on energy efficiency. There is not a single barrier that keeps energy-efficient housing from taking off. A whole range of issues has to be considered. Commercialisation of energy efficient single-family houses comes close to the problems of commercialising any environmentally sustainable product. They come in conflict with the current industry structures, organisations and institutions and with the general behaviour of different, related actors. In this situation, special measures are needed to promote commercialisation. The transition to sustainability needs to be managed.

Earlier research findings on energy efficient building, conducted by VTT, are now complemented by this study. We have identified major trends paving the way towards business from sustainability. Our focus was on three strategic issues:

1. Demand and supply of niche products, i.e. energy efficient single-family houses;
2. Drivers for business potential and opportunities;
3. Management of transition to environmentally sustainable business.

Preface

Buildings and particularly their use have a significant environmental impact and thus more sustainable solutions are gravely needed. It is estimated that buildings are responsible for 34 per cent of the total Finnish energy consumption. On the level of the European Union the figure even exceeds 40 per cent. Thus, a considerable savings potential exist. The energy consumption of buildings is something that needs emphasis, if Finland wants to meet its target in reducing carbon dioxide emissions and thus fighting climate change. Energy saving is our biggest unexploited source of energy.

Sustainable development and development of the knowledge society will affect the production, supply chains and delivery modes of buildings, as well as in-use services. The major demand for housing and primary market area for eco-efficient construction is single-family housing. The basic assumption is that in future only eco-efficient solutions will be acceptable in the aftermarket.

This publication was made in co-operation between VTT and Helsinki School of Economics, combining our different perspectives and earlier research findings.

Espoo, September 2005

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Contents

1. Introduction

1.1 Background

The building sector is responsible for more than 40 per cent of final energy consumption in the European Community. Furthermore, the figure is increasing. This trend is bound to increase the carbon dioxide emissions within the Community. The requirements of the Kyoto protocol call for measures to drastically decrease these emissions. To achieve its target level, the Finnish government looks for means. The government has much interest to promote energy efficient building (EC Directive 2002/91/EC; Government Programme, 2003).

The more than 10 000 single-family houses that are built yearly represent a considerable potential. Since the number has been on the rise during the past few years, the importance of this type of building has equally increased. Based on the fact that single-family housing is the preferred way of living among Finns, and considering the currently low interest rates, it seems likely that the trend will continue. According to studies, over 80 per cent of Finnish people would like to live in single-family houses. However, this is only possible for roughly 50 per cent of the population, as apartment buildings have been emphasised, due to the heavy migration of the past decades (Mikkola & Riihimäki, 2002).

If the perspective of an individual is considered, housing is a topic that has an effect on everybody. For most of us, the purchase of a house is by far the biggest investment during the lifetime. It is only reasonable to demand that the people making this investment be entitled to a reasonable and healthy living environment. Taken this, single-family houses are something to put emphasis on when promoting energy efficiency.

The topic is current also from a regulatory point of view. Given the new regulations from the fall of 2003 and the recent EU-directive, a considerable amount of emphasis has and will be put on the subject. The construction and housing industry will see significant changes in the near future.

The Finnish government promotes single-family housing in its program (Government Programme, 2003). There has been a steady annual growth in the number single-family houses built in Finland. In 2004, the construction of approximately 14 500 single-family houses was started and if terraced and linked houses are included, the number is close to 20 000 (Pientalobarometri, 2004). However, the traditional Finnish way of building is going through changes. Today, some 60 to 70 per cent of single-family houses are sold and built prefabricated. In addition, turnkey construction is becoming more popular, especially in Southern Finland. Giving up the conventional do-it-yourself thinking opens up opportunities in the field (Mikkola & Riihimäki, 2002).

The Finnish Ministry of Environment enforced new regulations concerning e.g. thermal insulation in the fall of 2003. This meant an improvement of 20–30 per cent to the thermal insulation of new buildings. In addition, the European Community introduced a directive on the energy performance of buildings in 2002, which sets various demands on single-family houses. However, it is possible to build houses clearly more energy efficiently than the new regulations require. This offers many benefits. An energy efficient single-family house is a financially sound investment, but also a healthy living environment (Ministry of the Environment, 2004; Nieminen et al., 2003).

Why is the market interest in energy efficient houses still low? Is it because consumers do not want to pay a higher initial investment cost? Are consumers interested or aware of energy related issues? Are the constructors unwilling to push these products to the market in a situation where price seems to be the only source of competitive advantage? Surely there is not a single barrier that keeps energy-efficient housing from taking off.

Commercialisation of energy efficient single-family houses comes close to the problems of commercialising any environmentally sustainable products. They come in conflict with the current industry structures, organisations and institutions and with the general behaviour of different, related actors. In this situation, special measures are needed to promote commercialisation. The transition to sustainability needs to be managed.

The challenge is summarised in Figure 1. How to take into consideration environment, social aspects and economy at the same time? How to formulate supply to meet demand trough complex set of criteria?

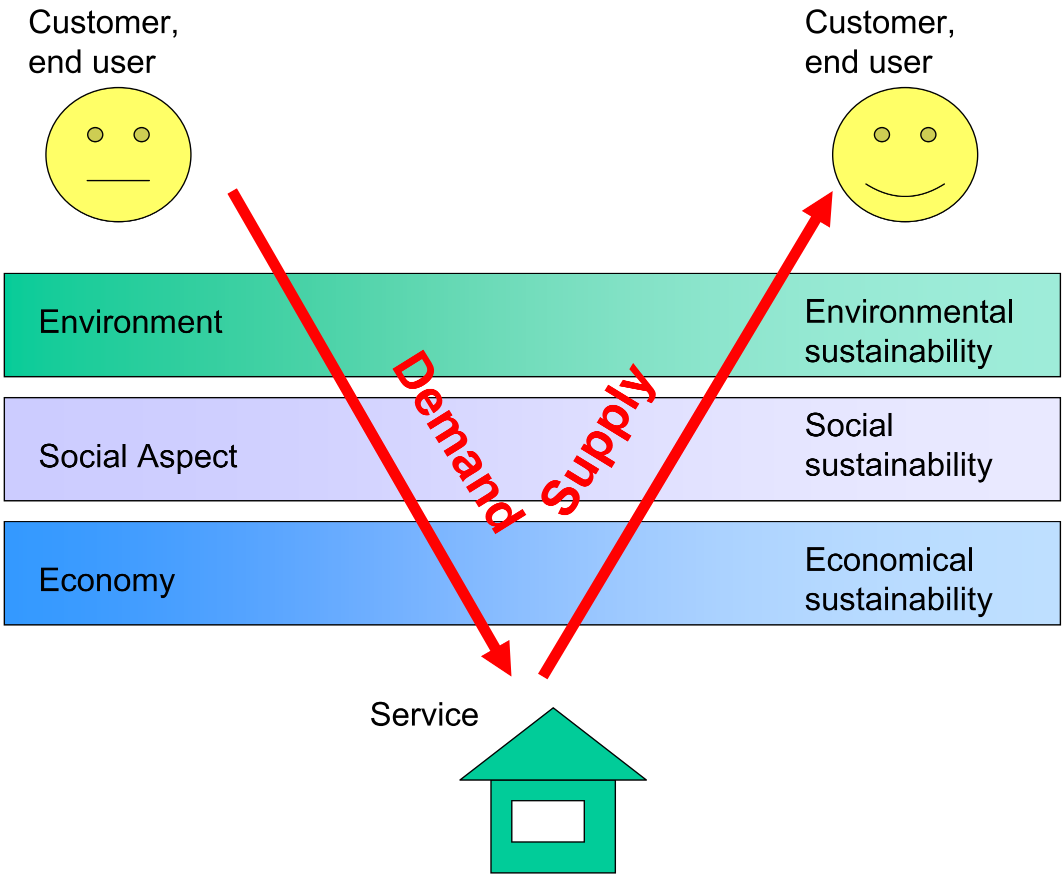

Figure 1. Future challenges, seen from angles of demand and supply (delivery).

1.2 Objectives

There is not a single barrier that keeps energy-efficient housing from taking off. A whole range of issues has to be considered. As there is little research available on the business possibilities of energy efficient single-family houses, the goal of this study is to form a big picture and thus serve as a basis for further research. Earlier research findings on energy efficient building, conducted by VTT, are now complemented by this study. Our focus is on energy efficient single-family houses:

1. Demand and supply of niche products (energy efficient single-family houses)
2. Drivers for business potential and opportunities
3. Management of transition to environmentally sustainable business.

2. From Technology to Business

2.1 What is Energy Efficiency in Buildings?

The definition of energy efficiency in buildings is somewhat ambiguous. Energy efficient buildings and low energy buildings are frequently used as synonyms. The term *low energy* is often not clearly defined in studies and publications. A major goal of low energy building projects and studies is usually to minimise the amount of external purchased energy such as electricity. However, sometimes the focus may be on the energy costs or on a particular form of energy input to the building. As building design needs to consider other issues as well, such a simple and straightforward definition is often not applicable in real life. A practical goal of low energy building is to try to achieve the highest energy efficiency with the lowest possible need for energy within the economic limits of reason (Hui, 2001).

VTT defines low-energy building or energy efficient building as follows:

The scope of a low-energy building is to achieve comfortable, healthy and safe indoor climate. The construction is based on simple and well performing materials, structures and building services systems that fulfil the requirements set for the building.

Primary target for energy consumption is to reduce heating energy consumption at least by 50% compared to a house built according to requirements of the National Building Code 2003. Secondary target for energy consumption is to reduce the energy demand of building services and household electricity by design solutions, adequate dimensioning of systems, and selection of energy-efficient equipments and lighting devices.

The primary target of the design and construction is cost efficiency.

The reduction of heating energy consumption by simple and cost-efficient measures contributes to overall performance and properties of a house:

- Good, demand-based and controlled indoor climate is easy to maintain.
- As the building services systems are dimensioned to correspond to consumption the heating power demand, connection capacity, standing utility costs, heat exchangers and heating devices can be reduced.
- In a cold climate, no radiators are needed in front of windows to compensate the cold draft caused by cool window surfaces.
- Heat distribution can be chosen according to preferences. Traditional distribution by radiators is no longer necessary, and more economical systems like ventilation heating can be applied.

- Proper design and high quality construction includes cost-savings that cover the additional costs of energy-efficient building envelope almost entirely.

Highly efficient buildings with significantly lower energy consumption are achievable through good design practices and effective use of energy efficient technologies. In an ideal case, buildings can even act as producers rather than consumers of energy. The following chapter on energy efficient single-family houses draws heavily on these principles (Hui, 2001).

Energy-efficiency includes two related energy issues that need to be considered. The first issue is the energy required in the transport as a result of location and urban planning. Transport energy is affected by planning of the built environment, transport policies and systems and other social and economic factors. However, the issue of urban planning concerns overall urban policy and is not relevant to be considered on the building level. The second issue relates to embodied energy of buildings. Embodied energy of buildings refers to the energy input required to extract, transport and manufacture building materials, added with the energy used in the construction process. It represents the total life-cycle energy-use of building materials and systems. The importance of embodied energy depends on the time scale. In the climate of Finland, the long-turn focus emphasizes the importance of operating energy. For an energy efficient building the short term focus may emphasize the importance of embodied energy. However, as a guideline energy efficiency is always important.

2.1.1 Energy Efficient Single-Family House

It is difficult to define energy efficient buildings in other ways than focusing on the energy consumption of the building itself. Energy consumption can be divided into three categories:

- Energy demand to maintain good living conditions (heating energy)
- Energy demand for required for the building services systems
- Energy demand for occupants’ habits and activities (hot water heating, household electricity).

Table 1 shows examples of these consumption categories for buildings of different ages.

Table 1. Energy consumption in detached houses of different ages. The consumptions given describe the energy consumption in the present condition of buildings.

Consumption	->1960	1960–>	1970–>	1980–>	Present	Energy-efficient
Energy demand to maintain good living conditions, kWh/m² year						
Space heating	160–180	160–200	120–160	100–140	80–120	40–60
Energy demand for fans, pumps, lights etc., kWh/m² year						
Building electricity	20–30	20–30	20–40	20–40	10–30	10–30
Energy demand for occupancy, kWh/m² year						
Hot water	20–60	20–60	20–60	20–60	20–50	20–40
Household electricity	20–40	20–40	20–40	20–40	20–40	20–30
Total, kWh/m² year						
Total consumption	220–310	220–330	180–300	160–280	130–240	90–160

Various ways and principles exist in designing energy efficient single-family houses. Energy efficiency is achievable through different means. Increasing thermal insulation, reducing air leakage, recovering heat from exhaust air, using special low-energy windows and extracting energy with heat pumps are examples of the variety of ways that exist. In practice the solutions are usually a combination of different means. Besides the technical solutions, it is important to point out that the most important means for energy efficiency is the user itself (Saastamoinen, 1994).

One approach has received considerable emphasis in many studies conducted on energy efficient single-family houses at VTT. According to VTT research on the subject, a leading principle for designing energy efficient low-energy houses is to create a comfortable, healthy and safe indoor climate with as simplified solutions as possible. This is to be achieved without compromises in structures or equipment. Emphasising other qualities besides energy efficiency is important, as sustainable products are concerned (Halme et al., 2004a; Halme et al., 2004b). The goal is to reach a significant reduction in the consumption of heating energy compared to a house built according to the Finnish energy standards for housing. As heating accounts for most of the energy consumed by a house, this is central when improving energy efficiency. In addition, emphasis is put on cutting down the use of electricity (Nieminen et al., 2003).

According to the Association of Finnish Civil Engineers, RIL r.y. (2001), housing types can be ranked in terms of lifetime economy as a function of energy economy (Figure 2).

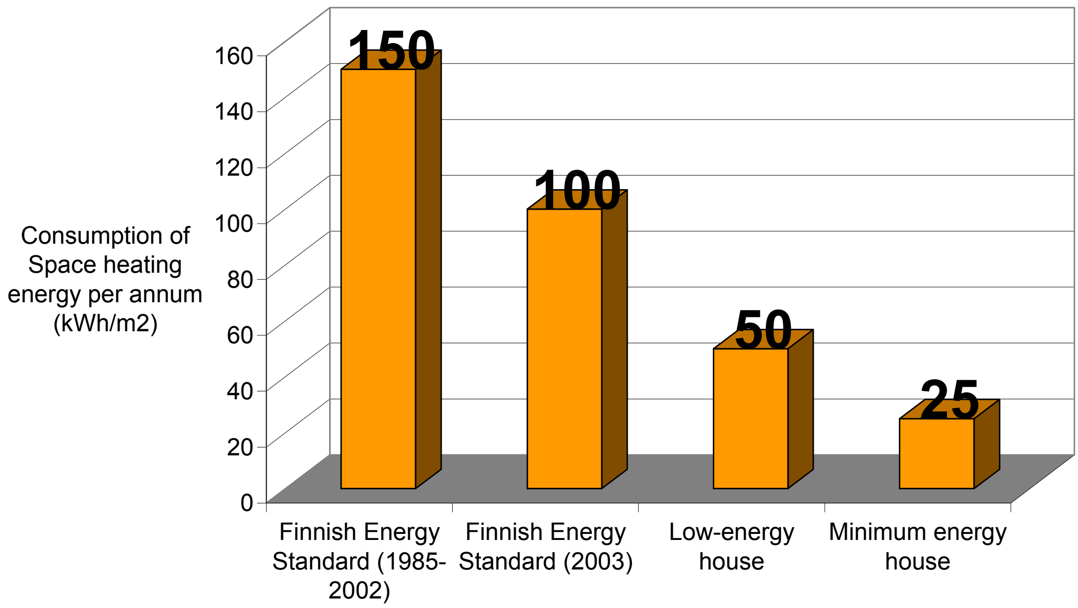

Figure 2. Housing types in terms of function of energy economy (RIL 2001). (The value for present Low-energy house is updated from Table 1: energy efficient house average = 50 kWh/m² per annum).

Given the low consumption of space heating energy, energy efficient houses do not require heavy heating systems and can take advantage of free energy sources. Solar radiation and internal sources of heat (e.g. household appliances and lighting) are enough to keep the house warm almost throughout the year. Due to the effective thermal insulation, special emphasis has to be put on ventilation. If used wisely, ventilation in such a house can actually be used to take care of the whole heating. This allows a simpler structure when radiators or such are not needed and results in cost savings which practically covers the extra costs caused by better thermal insulation (Nieminen et al., 2003).

When planning an energy efficient single-family house the main systems and solutions should be chosen at an initial stage. Additionally, the house should be seen as a whole, not something constructed of different parts. The bases of planning energy efficient houses include the following (Nieminen et al., 2003):

- Reduced heathing heat loss by 50 per cent compared to standards
- Controlled ventilation and heat recovery from exhaust air
- Use and control of heating and ventilation according to actual needs
- Utilisation of free internal and external sources energy in heating
- Controlled use of water

- Thorough planning and implementation
- Simplification of technology, reduction in the number of parts
- Use of energy efficient appliances.

2.1.2 Prefabricated Houses

A growing number of single-family houses are built prefabricated. For the year 2004, it is estimated that prefabricated houses represent 64 per cent of the total single-family houses built during the year. In addition, more and more prefabricated single-family houses are sold as turnkey construction (Pientalobarometri 1/2004).

Simplified, prefabricated housing as a concept means single-family houses sold as "packages". This package includes materials and possible setting up or partial setting up of the house. Prefabricated houses are often categorised in terms of material used, way of prefabrication and type of setting up the house. These categories include for example houses made of prefabricated wood, log or concrete units; wood being the most popular. Additionally, *Precut* and *Platform* techniques are associated with these houses. They are among the recent systems for constructing wood framed prefabricated houses. In a Precut system all the main parts of the frame are constructed in a factory, cut and assembled again at the site according to a special numbering. This system minimises the time spent at the actual building site. When using a Platform technique, the actual construction takes place at the site but the parts and materials are standardised (Riihimäki & Lehtinen, 2000).

One way to categorise prefabricated houses is in terms of setting up the actual building. Builders have many options. They can choose to do the whole construction work themselves or just parts of it. The other extreme is to choose turnkey construction. This means that the homebuilder customer involves as little as possible in the building process. The most popular way is to have the house partially set up by the building company. Around 75 per cent choose this option. However, turnkey construction is becoming more and more popular in Finland. There are many reasons behind its popularity. Firstly, the generally higher standard of living allows this type of construction, as people have more money to be spent on housing. Secondly, the number of people with skills to set up a house is getting smaller and smaller. A clear sign of these two is the fact that turnkey construction is most popular in Uusimaa province, close to the capital region, where people in general are not considered experienced in doing construction work. Uusimaa province is also the most important region for prefabricated houses. According to Pientalobarometri (1/2003), the percentage of people taking part in the construction work shows a declining trend. Thirdly, the current busy way of living contributes to the popularity of turnkey construction (Riihimäki & Lehtinen, 2000).

Considering the growing popularity of prefabricated houses and the importance of single-family houses to the total energy consumption of buildings, significant emphasis should be put on promoting the energy efficiency of these houses. If providers of prefabricated single-family houses concentrated on energy efficiency, the long-term effects would be considerable. It is estimated that the construction of approximately 14 500 single-family and 5 500 terraced houses were started in 2004. Using the previously mentioned percentage for prefabricated houses, it means that the building of over 9000 prefabricated single-family is started in 2004. Besides, the number is increasing (Pientalobarometri 1/2004).

2.2 Benefits of Energy Efficient Single-Family House

Energy efficient housing offers many individual level benefits, but in order to assess them one should have a long-term perspective. As heating accounts for a majority of the life cycle costs of a house, energy efficiency means substantial cost savings. According to Nieminen et al. (2003), life cycle costs are 10 to 30 per cent lower compared to a regular house, depending on cycle length, need for finance and price development of energy. As the initial investment cost is from zero to five per cent higher, the payback period of an energy efficient house is under ten years. Payback periods of four to five years have also been reported. Considering the recent speculations about increasing energy prices, the importance of life cycle costs is bound to increase. In this situation, an energy efficient single-family house is something to be reckoned with (Kara, 2004).

The benefits of energy efficient single-family houses in terms of energy costs are easily illustrated with a simple graph on basic level. Consider an electric heated single-family house of 150 square meters. Figure 3 depicts the annual heating costs of such a house on different energy prices depending on the energy consumption of the house. The previously presented ranking by RIL is used as a guideline in the graph. A starting value of 0,08 €/kWh is used for the price of energy. This was somewhat an average price for such a house in the time of this study (2004–2005). As seen in the graph, energy efficient alternatives have a clear advantage. The difference in annual energy costs is clear already, but becomes even more significant, if energy prices are to increase. This is especially true in the case of minimum energy houses. The graph does not consider bulk discounts, but gives a ballpark estimate of the annual heating costs. One should also notice that many of the existing single-family houses do not even meet the 1985–2002 standards, which puts them in an even worse situation, if energy prices are to increase (Energiamarkkinavirasto, 2004).

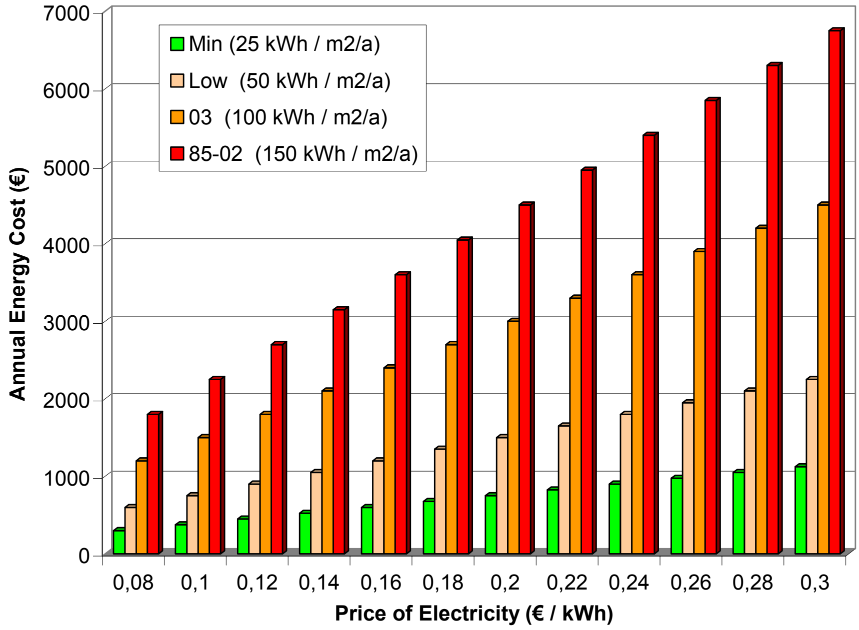

Figure 3. Heating costs depend on method of construction. The calculation is based on the 150 m^2 single family house.

In addition to the decreased energy and life cycle costs, the resale value of an energy efficient single-family house is claimed to be 10 to 30 per cent higher. In the secondary markets of tomorrow, it is likely that energy efficient houses will have a big advantage. The importance of the resale value was also noted in a recent article by Talli (2004). 34 per cent of homebuilders consider the expected resale value as the most important feature of a new house. It is only reasonable that the people making the biggest investment of their lives get value for their money (Nieminen et al., 2003).

2.2.1 Life-Cycle Cost

The need for renovation of a house comes from two sources: reduced technical condition of the building components, and the spaces and appearance of the house becoming old-fashioned. The need and extend for such renovation measures depends largely on the target setting in the early design phase. The need for future renovations can be reduced by taking the future needs into account in the design. Therefore it is important that the builder and the design team work together to find out the needs of the first user of the house, and try to settle these needs with a view to the future performance of the house. Systems serving as a platform for decision-making have been developed in a number of international frameworks. An example of such a system is described in Table 2.

Table 2. VTT ProP® Property Classification.

A CONFORMITY	B PERFORMANCE	C COST AND ENVIRONMENTAL PROPERTIES	D PROCESS
A1 Location A2 Services	B1 Indoor conditions B2 Service life B3 Adaptability B4 Safety B5 Comfort B6 Accessibility B7 Usability	C1 Life-cycle costs C2 Environmental pressure	D1 Briefing/Programming D2 Procurement D3 Commissioning D4 Operation
Eco-efficiency = (conformity + performance) / (environmental pressure)		Cost efficiency = (conformity + performance) / (life cycle costs)	

Table 3 shows a relative cost analysis of different heat generators serving for a floor heating system. The cost levels are adopted for the whole system including heat generator, distribution and control. The floor structure is the same in all of the cases, and thus the investment cost for the floor structure and installation of the distribution system (pipe system for water circulation or electrical cables) can be assumed to be the same for all systems.

Table 3. Relative cost analysis of heating system costs, Nieminen et al. (2005).

Detached house 150 m^2	Ground heat COP = 3	Electric heating	District heating
Energy consumption: MWh/20 years			
Heating energy			220
Electrical energy	74	220	
Acquisition cost, €	**15 000**	**7 000**	**10 500**
Costs: €/ 20 years			
Financing cost	3 300	1 540	2 310
Maintenance	2 000	1 000	1 000
Standing costs	1 280	2 420	7 680
Heating costs	5 420	16 100	8 950
Total	**12 000**	**21 060**	**19 940**
Life-cycle cost, €	**27 000**	**28 060**	**30 440**

The cost differences in the investment phase are evened out in a time frame of 20 years. On a life-cycle perspective, the heating system can be selected according to builder's wishes. The district heating system and ground heat pump are more economical if two or more houses utilize the same heat generation system.

The direct benefits of eco-efficiency are given in Table 4. For a housing provider eco-efficiency serves for improved return and running costs. In general the importance of eco-efficiency can be given as:

- Acquisition costs: 0–5% higher than with typical construction
- Life-cycle costs: 10-30% lower than with typical construction
- Life-cycle profit: 30–50% better than with typical construction
- After market value: 10–30% better compared to typical construction.

Table 4. Direct benefits of eco-efficiency for a home builder, Nieminen et al. (2005).

Location:Tuusniemi Reference period 20 years Real interest rate: 2% **Cost properties**	**Typical house** 150 m^2 €/m^2		**Eco-efficient house** 150 m^2 €/m^2	
Acquisition cost **Aq**$_i$	**1 370**		**1 405**	
Financing cost: loan for 60% of acquisition cost/15 years	140		145	
Maintenance cost (actions defined in house manual)	100		90	
Operating cost	355		180	
Heating energy		*110*		*35*
Electrical energy		*40*		*35*
Other operating cost		*80*		*40*
Adaptability cost; changes in floor plan		*35*		*20*
Risk cost; damages that can not be anticipated		*40*		*30*
Development cost; for adaptability		*50*		*20*
Life-cycle cost **LCC**	**1 965**		**1 820**	
Life-cycle income **LCI**	2 040		2 040	
Life-cycle economy **LCE = LCI-LCC**	+75		+220	
Resale value **RV**	1 000		1 200	
Life-cycle profit **LCP=(LCE+RV)/(Aq x t)**	3,9%/a		5,1%/a	

2.3 Business Opportunities

The above shows that energy-efficient single family houses are cost-efficient in terms of their life-cycle cost. However, this fact alone is not sufficiently substantial to make most consumers choose such a housing option. Actually, one of the pronounced problems is that the investment cost of an energy-efficient house at the time of the actual investment can be higher than of an ordinary house. Moreover, eco-efficiency is not a key driver for many. Consumers, that is families choosing their pre-fabricated home, must be able to derive other benefits as well. They seek for comfort, style, healthy house, safety and the like. In the choice equation of an ordinary family, energy-efficiency is an additional benefit rather than the first choice criteria. Therefore the marketers of energy-efficient prefabricated single-family houses should emphasize also these other characteristics aside of environmental and cost aspects.

Thus, business opportunities for energy-efficient housing do exist, but marketing must be streamlined. Firstly, other benefits such as comfort, health effects, safety aspects and long-term cost-efficiency ought to be made clear in marketing efforts. Secondly, prefabricated house builders are not construction professionals and therefore they should be offered easy, reliable house alternatives so that they do not have to pick single energy-efficiency features for the house by themselves. There is latent demand for energy-efficient houses, and the market niche exists for those housing providers that are able to offer reliable prefabricated house options and make them easily available for the builders.

All and all, energy efficient single-family houses provide means for taking a turn to sustainability in the housing and construction sector.

2.3.1 The Confused Builder-Consumer

Up to now most homebuilders are not focused on energy efficiency. Home building is a challenging task for any builder who is not a professional of the field – which is the case for most of those building a prefabricated single-family house. The task of building a house stretches the limits of an ordinary builder family in a number of ways: the economic investment is big, the required start-up knowledge and capabilities are seldom sufficient for the task and, furthermore, time becomes a scarce resource. In this situation it is only natural that most homebuilders try to streamline and easen the building process as well as minimize the involved risks in all possible ways. This leads to selection of well-know materials, technologies and components and hence exclusion of unfamiliar and risky ones – and as mentioned earlier, to choice of alternatives that involve the lowest up-front investment cost.

How does the above relate to energy efficiency of prefabricated single-family houses? Energy efficient solutions are usually not the most well-known ones and in many instances their investment cost is slightly higher than those of the ordinary solutions. The pay-back periods are not overly long and in a long-run cost savings accrue from energy savings, but at the time of investment many families are pushed to the limits of affordability. In Finland this problem is pronounced in the capital area, because of the high prices of the building land. But higher investment costs are far from the only problem in the way of energy efficient home building. Energy efficient technologies and materials also tend to be less well-known, and hence bear greater uncertainty from the builder's perspective than ordinary solutions. This uncertainty is aggravated by the fact that the marketers of prefabricated single-family houses are not experts of energy efficiency either. Thus even those homebuilders that might be interested in energy efficiency of their future home, often become discouraged and end up choosing materials and technologies that are not energy efficient. Mainly only those homebuilders that are aware of energy efficient solutions or behold strong environmental or other values favouring energy efficiency, actually end up building an energy efficient house.

2.3.2 Marketing Response: Full Concept and Branding

In this report we have discussed the jointly coordinated efforts of many actors that are needed in order to promote energy efficient single-family housing. There are, however, steps that are possible prior to such major changes in the regime that have been outlined in the section 'Strategic niche management'. With skilful marketing, it is possible for even one single entrepreneur to forward energy efficient single-family housing and gain markets by doing that – and indeed pave the way or make an impact on the shift of regime.

The first task for an enterprise is to recognise the segment of potential customers. As of yet, the mass market would not react to the marketing claims of energy efficient housing. There are, however, some consumer segments that are open to the message. These segments differ from one another. Based on earlier studies we can distinguish at least two profiles for the potential customers of energy efficient houses, namely the environmentally-oriented homebuilders and the long-term cost-oriented ones (Halme et al. 2005, Thøgersen and Ölander, 2003). Based on the empirical research done for this report (Savonen, 2004), we assume that in the prefabricated homes market there is yet another customer profile, the "wealthy segment", i.e. homebuilders who can easily afford to invest more up-front, but who are anyhow keen on saving in long-term operating costs. Moreover, there are some implications that people with allergies or similar type of health problems might be more open to energy efficient housing solutions, provided that they involve articulated health benefits, such as better indoor air quality.

Having said the above, we also want to emphasize that energy-efficiency cannot be the main or the sole marketing argument for a prefabricated home. The house must still be functional, of good quality and please the aesthetic tastes.

Provided that a prefabricated homes manufacturer would like to market to the above mentioned customer segments, the product (house) must be in the first place be available as a full product concept. The homebuilder should not be forced to search for the energy efficient technologies and/or materials and compose the house like a puzzle. Moreover, branding should be utilized better than is presently done. We pointed out that one of the problems is the lack of knowledge and uncertainty related to the technological energy-efficient solutions. To overcome this barrier, there should be products that clearly carry the profile of "low-energy houses", "healthy-life houses" or the like. This would simplify the customer choice. Trustworthiness is one of the problems that immediately arise when this kind brand is introduced. Who should be the party to assure the customer that the claim really holds and is not just another marketing gimmick?

Here is it perhaps possible to loosely apply a concept that known from more simple products' context: labelling. It goes without saying that the concept of labelling cannot be applied in a similar fashion to products like tissue paper or washing detergent. Type three environmental labelling is a labelling procedure that already comes a bit nearer to what could be used with houses: check-list type concept which helps the customer to understand what energy efficient features the house has. Already for the time being Motiva, the Centre for Energy Efficiency, has such a check-list. Its use could be further developed for the purposes of communicating the energy efficiency features to homebuilders. This would require cooperation between Motiva and a prefabricated home manufacturer. The EU energy certificate is on its way, but it can be pre-emptied and strengthened with a label.

In addition to branding, marketing energy efficient prefabricated houses also calls for other arguments than those that appeal to technological rationalities and cost savings. If marketed also with other kind of argumentation like healthiness for children (good indoor air quality), 'pleasurable to live in', 'ecologically friendliness', it would offer yet another leverage to the buying decision of a builder family. Namely, it is increasingly true that not only male 'heads of the family' make house decisions but that both spouses and occasionally also teenage children influence the decision. These arguments are likely to be more appealing to quite a few the female family members and teenage children alike. Diversified marketing claims (such as healthiness and energy efficiency) could make it easier for them to enter to the family discussion about house buying decision, and energy efficiency could win more ground as a decision factor.

3. Network Operations in Regional Construction

One of the challenges of sustainable construction is that the solutions are not merely technological ones, but involve several constituencies. Sustainable construction strives to minimize the consumption of energy and resources for all phases of the life cycle of buildings. This includes the whole process from land use strategies, design issues and decision making in planning and construction to use, renovation and disposal and demolition of buildings. The concept of eco-efficient construction is relatively well known, but the concept of network operations based new regional building is still under-developed. As the models for both eco-efficient buildings and neighbourhoods and operations models are implemented, the technology and process develop in the company networks.

3.1 Case Examples of Regional Construction in Finland

Municipality of Tuusniemi and City of Tampere are developing new residential areas. Housing concepts including a model house based on high energy-efficiency housing were developed for both locations. It is quite important to study the characteristics connected to housing area and living on a housing area together. This ensures that the desired eco-efficiency properties can be achieved (Nieminen et al., 2005).

3.1.1 Tuusniemi

Tuusniemi is a rural municipality in East Finland. It is located in less than one hour travel time from two major regional growth centres and university towns Kuopio and Joensuu. The Tuusniemi municipality suffers from depopulation and distortion of age structure. Due to poor working possibilities, young people move to other locations. This causes growing socio-economic problems. The municipality decided to persuade new inhabitants by offering high-class but affordable housing possibilities. The housing area enables remote working with working facilities for common use. All the houses will have high-standard internet connections. Public services, schools, nursery, health care centre etc. are available within walking distance. Public transport connections serve for working in the nearby cities.

The Hietaranta housing area in Tuusniemi is located between two lakes, both with extremely pure water, and bounded by traditional rural cultivated area. Peaceful, pure, and safe environment together with eco-efficient housing were chosen as targets for the new housing area. The project demonstrates how eco-efficiency can be utilized as drivers in community economics, new business activities, and employment in municipalities outside growth centres.

Model House

The model house was designed according to the desired performance characteristics describing the user requirements and environmental targets of the house. VTT's Requirements Management Tool EcoProp (2003) was used in setting the requirements. Requirements for the technical design were derived from the performance requirements:

- The house is adaptable with regard to both size and floor plan.
- The wooden house serves for short delivery cycle at site and simple thermal insulation system. The load-bearing wooden frame is single-framed allowing for high levels of insulation. Comfort is taken into account in all dimensioning of structures.
- The house is energy-efficient. The heating energy demand of the house is less than 50% compared to a house according to national building code of 2003, and less than 35% compared to typical buildings before 2003. Heating energy consumption can be decreased further by building service systems. Appliances and heating and ventilation equipments are energy labeled (class A).
- The house has a long-service life. The durability of the wooden envelope structures is improved by environmentally friendly wood preservatives. The coloring of the house is based on tinctures traditionally used in wooden houses. The house has a tilted roof for facade protection.
- The house has a good and healthy indoor climate. The adaptability of the house is taken into account in the design of building services. The materials and solutions support good and healthy indoor environment.

Distributed Energy Systems

In Tuusniemi, the natural environment connected to safe and traditional village structure was set as a target. Until now, typical heating system in Finnish houses is direct electric heating system. To be able to reduce the number of direct electric heating systems and at the same time the power demand of the area, builders have a possibility to join the distributed heating energy system, and to utilize wind energy as a primary electricity source. The municipality offers the connection to as a communal network. Three alternatives were considered for a distributed heating energy network:

- High temperature biomass plant (T = 80/43 ^{o}C) using local energy sources.
- Centralized ground heat distribution system (T = 50/40 ^{o}C) with separate hot water system in the houses.

- Distributed low temperature ground heat system (T = 2/-1 ^{o}C) with individual heat pumps.

A cost analysis showed that the low temperature distributed ground heat system (Figure 4) is cost efficient for both the municipality with regard the construction costs and the builders with regard the life-cycle costs. The investment cost for the ground collector systems is roughly 35–45 €/floor-m^2 of houses. The costs are dependent on the plot ratio of the area. As the plot ratio for the Tuusniemi housing area is extremely low, the costs for a total network is high. If the network can be divided into sub networks, the costs will be reduced down to 25–35 €/floor-m^2. The ground system uses water soluble and environmentally safe heat carrier.

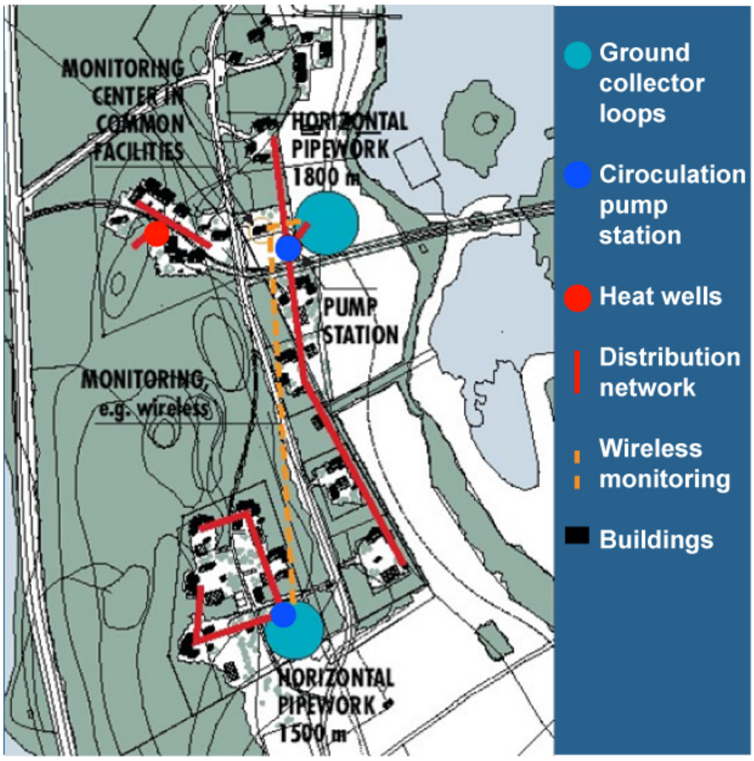

Figure 4. Ground heat systems in Tuusniemi: Ground pipework for heat collection depends on ground conditions. Horizontal pipework is used in soil with clay, and heat wells in rock. The system is quite competitive with district heating network costs (Nieminen et al. To be published 2005.).

Business Opportunities

More than 75% of detached houses are built of wood in Finland. Wood as the basic construction material is a natural choice in Tuusniemi. Material is available locally. The project supports local building products' industry by knowledge sharing and showing new business opportunities. The house is built using local resources. A labelling procedure for local forest products was developed. The system enables the builder to verify the wood-processing from the forest to the building site. The labelling system covers only the Tuusniemi region. Indication of origin is still a new issue to Finnish wood products industry. In present production process wood products may be transported long distances (forest ⇒ sawmill ⇒ sales service ⇒ customer) before entering the building site, even though material is typically available almost everywhere in Finland right in the neighbourhood of the construction site.

3.1.2 Tampere

Whereas the Tuusniemi housing area is based on traditional village structure of the region with rather large sites, and master plan, taking into account the natural values of the area, the Tampere housing area is aiming at a city-type structure with low and dense quarters for low construction. Tampere region is one of the fastest growing economical areas in Finland. The population of Tampere and its surroundings are expected to grow by 30 000–50 000 inhabitants by the year 2020. New housing is required to cover the demand. The city of Tampere together with neighbouring municipality of Lempäälä are developing a housing area for 13 500 inhabitants, 6000 working places and services. Sustainable development has driven the early master planning. The whole region includes planning areas where new solutions and process models are tested. These areas include sustainable energy models, process models for integration of master planning and building design as well as new procurement, tendering and contracting practices. Integration of the area with the existing surrounding urban structure is an important planning issue. The area is close to a concentration of high tech in Hervanta.

Placement of Buildings

In Tampere, natural values of the area were examined and taken into account in the preliminary master planning work. Nature and connection to the nature was the starting point to the whole development. The microclimate of the area was analyzed according to solar gain (orientation of slopes), local temperature variations (cold air lakes, cold air flows, open water areas balancing temperatures) and significant wind directions. These studies guide the placement of the buildings. Passive solar heating opportunities should be maximally exploited in positioning and designing the buildings.

Distributed Energy Systems

Major part of the area will be covered by co-generated heat and power produced with natural gas, peat and biomass as primary energy sources. Also roughly 5% of the electricity demand can be covered by hydropower. Distributed heat pump systems can be utilized in areas where district heat is not economical. The possibilities are to use lake water or heat wells as ground heat sources (Figure 5). The system costs range from

7 to 9 €/floor-m^2 for the heat collector systems only, as an average cost level for distribution network for district heating varies roughly between 10 and 15 €/floor-m^2.

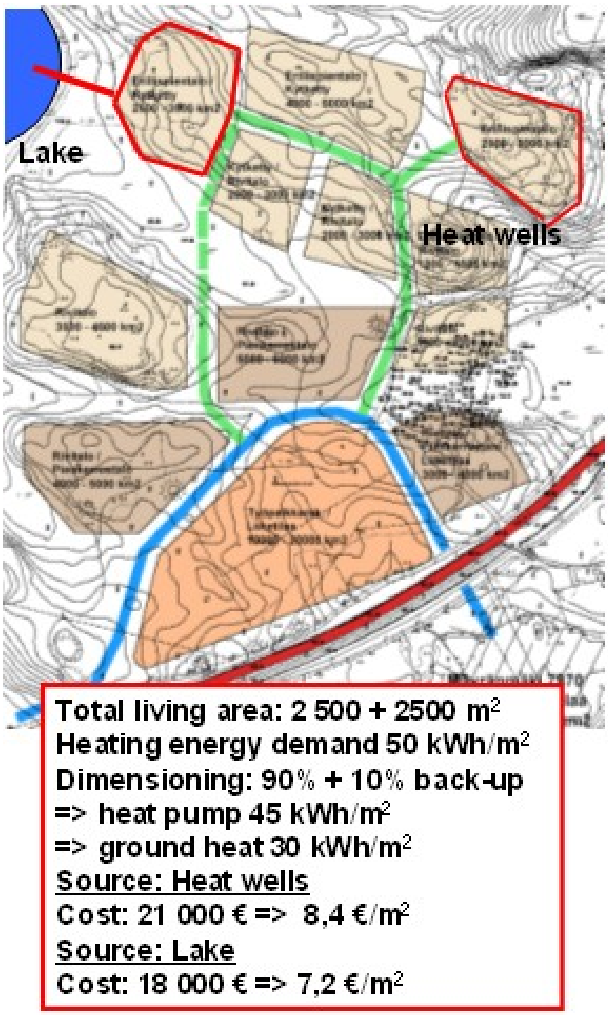

Figure 5. Ground heat systems in Tampere: Ground heat can be collected from heat wells or from a lake. The system is quite competitive with district heating network costs (Nieminen et al. To be published 2005.).

4. Challenges of Energy Efficiency Related Business

4.1 Characteristics of the Construction Industry

It is important to understand development of the Finnish construction industry and its typical characteristics. It is important to understand why change in the field is slow and why business with environmentally sustainable products, such as energy efficient single-family houses, is difficult to conduct.

The Finnish construction industry has been characterised by the strong role of the society and a high dependence on economic development. The operational environment has been largely shaped by housing, regional and social policies of the government. Heavy migration and the rapidly changing society forced the industry to fast building and short-term cost-efficiency. The basis for this type of building was not on end user needs and market-based requirements. The focus was rather on costs and fast building. This unstable and policy-driven demand for the products did not encourage to research and development activities or innovativeness (Koivu et al., 2001).

The industry is traditionally strongly engineering- and project based. Not much focus has been put on customers, marketing or communications. This traditional product orientation has hindered the development of the sector. User needs have not forced the industry to development, as customer orientation has been almost non-existent. Additionally, the fragmented and project-based structure of the industry has caused problems. Networking and communication in general between various industry players has been low. As innovations often need interaction to be born, the lack of long-term co-operation is an obvious disadvantage (Koivu et al., 2001).

Most of the industry firms are small or medium sized. When developing new solutions involves risks and testing in real situations is expensive, small firms often feel that it is impossible to engage or invest in development activities. In practice cost savings seem to be the only source of competitive advantage and motive of investment. Focusing on differentiation is rare (Koivu et al., 2001).

In the construction industry, energy efficiency has largely been promoted through legislation and building regulations. They have been targeted to foster the adoption of energy conserving appliances and structural solutions. However, recently emphasis has also been put on market based development. Energy efficient building was meant to become a profitable business. It was thought that promoting voluntariness would enforce innovativeness within the industry. A market-based approach was believed to change attitudes more effectively, compared to legislation and regulations. Despite the efforts, the market-based approach did not turn out to be successful and, thus, improvements in energy efficiency have been largely based on legislation (Niva & Uotila, 1996; Sunikka & Klunder, 2000).

4.2 Transition Management

4.2.1 Tensions within Socio-Technical Regimes

In the case of the socio-technical regime that characterises single-family houses, various issues causing tension and misalignment can be identified. Some comments from recent stakeholder interviews (Savonen 2005) around the issue give good examples of the range of issues:

"Energy issues should become more important to consumers. A change of attitudes is needed", social actor representative.

"Resale value and emphasis on costs open up opportunities for energy efficient building", producer representative.

"Increasing energy price has a major effect. In Europe, where the price is already higher, effects can be seen", producer representative.

"Women and teenagers are an important focus group. They are often behind investment decisions", producer representative.

Two major changes within a short timeframe cause tension (Savonen, 2005): The recently revised building code and the coming directive requirements concerning the minimum energy performance requirements were seen to put pressure to the construction industry. Producers are forced to adapt to the new regulations.

4.2.2 Strategic Niche Management and Social Embedding

Niches need to be managed, in order to make use of the "windows of opportunity" that may open up in the socio-technical regime. Strategic niche management offers a framework to control these niche experiments that are critical in the transition process. Using this framework, two case examples, Hietaranta and MotiVoittaja are analysed.

The concept of strategic niche management is another example of the Dutch research on transitions (Geels, 2004; Kemp et al., 1998; Weber & Dorda, 1999). Dutch scholars propose the following definition:

“Strategic niche management is the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technology and (2) enhancing the further development and the rate of application of the new technology” (Kemp et al., 1998).

The underlying idea in strategic niche management is to provide a protected space for an experiment to help it gain wider acceptance. These early markets form the needed support group around the experiment. They are not meant just to demonstrate the viability of a concept, but to provide an opportunity to learn and adapt. The aim is to bring together different actors to shape the experiment to make it match with the needs of the actor group as well as possible. This is also the key to achieve wider acceptance and thus a commercialised product (Weber & Dorda, 1999; Kemp et al., 1998).

Unlike the common technology-push approach, strategic niche management does not address the commercialisation process only in terms of its technological aspects, but also from its socio-economic context. It pays attention to building of support networks and aims to combine the interests of different essential actors involved. It raises future users as the most important stakeholder group, as it is them that finally decide whether an experiment becomes successful or not. The goal is to try to establish a common understanding of actor expectations and improve the long-term development potential of the experiment at hand. The niche approach allows a promising experiment to benefit from the actual use and, thus, promote learning and develop a network around it (Weber & Dorda, 1999; Kemp et al., 1998).

Kemp et al. (1998) list more specifically the aims of the approach:

- to articulate the changes in technology and in the institutional framework that are necessary for the economic success of the new technology
- to learn more about the technical and economical feasibility and environmental gains of different technology options, i.e. to learn more about the social desirability of the options
- to stimulate the further development of these technologies, to achieve cost efficiencies in mass production, to promote the development of complementary technologies and skills and to stimulate changes in social organization that are important to the wider diffusion of the new technology
- to build a constituency behind a product – of firms, researchers, public authorities whose semi-coordinated actions are necessary to bring about a substantial shift in interconnected technologies and practices.

In order to promote learning and facilitate the articulation of needs and interests, interaction between the different actors is needed. Organised interaction between the actors can e.g. be in the form of workshops or seminars. The articulation process is in fact in the heart of Strategic Niche Management. Niche experiments are a way to stimulate the articulation processes that are necessary for the new solutions to become socially embedded (Kemp et al., 1998).

A Finnish application of Strategic Niche Management by Väyrynen, Kivisaari and Lovio (2002) has been named as Societal Embedding after the key purpose of the approach. Societal Embedding concentrates on an interactive learning process between three actor groups, namely producers, users and social actors. Like Strategic Niche Management, Societal Embedding aims at promoting co-operation between these actor groups, in order to fit the innovation to market needs and create favourable conditions for adaptation. Open dialogue between these groups to build a support network for alternative solutions lies at the heart of the method. The method strives at finding and shaping solutions that meet the needs and expectations of the key actors. Learning by doing, learning by using, and learning by interacting are important in reaching the goals.

The approach of Societal Embedding has been applied for example in the energy and health care sectors in Finland. Experiments include promoting a more widespread use of wood pellets and the ESCO service. In addition, chronic illnesses such as diabetes and hypertension have been tackled using this method (Kivisaari, 2004; Väyrynen et al., 2002; Kemp et al. 1998).

4.2.3 Five-Stage Process of Strategic Niche Management

A Niche Management project includes a number of consecutive elements. Kemp et al. (1998) and also Weber & Dorda (1999) describe a five-stage process. (1) It starts from the choice of technology or concept. The considered technology or concept should be as close as possible to the current regime, but which has the potential to offer more fundamental changes later on. (2) The second stage includes the selection and planning of an experiment. The experiment should be kept adequately broad when considering partners and in order to allow the participants to learn. In addition, opportunities for active involvement should be created. (3) The next step is the actual implementation of the experiment. Being the most difficult step, emphasis should be put on finding a balance for protection and market pressure. A compromise between long-term and short-term benefits is a recommended option. The policy chosen for the experiment should tackle the barriers that prevent the use and diffusion of the technology or concept at hand. Be these barriers economic, technical or social and institutional, an integrated and co-ordinated policy is required. Elements for such as policy could include formulation of long-term goals, creation of an actor network, co-ordination of actions and strategies, and possibly use of government measures. (4) The fourth step includes expanding the experiment to a niche. In this stage, support might still be needed to protect the experiment. It is important to try to replicate the experiment in order to adapt it to mass users. (5) The fifth and final step ends the process. In this stage the protection is broken down in phases, as support is no longer needed.

According to Kivisaari (2004), as a distinction to Strategic Niche Management, Societal Embedding is based on a cyclic view and emphasises certain fundamental questions throughout the process. These are:

1. What desired features characterise the product or service being developed?
2. Whose expertise and approval are fundamental to the development and diffusion of the product or service?
3. What are the key actor interests and how can these actors become committed?

These questions need reconsideration throughout the project, as it moves on and attains a more specific form.

4.3 Strategic Niche Management Perspective to Case Examples

4.3.1 Hietaranta (Tuusniemi)

Hietaranta project in Tuusniemi (Chapter 3.1.1) consists of three parts: ecological building and living, innovative timber construction, and quality living in the countryside. The following analysis by Savonen (2005) concentrates mainly on the building and living part. Evidently it is too early to evaluate the final success of the project. However, some conclusions can be made. Evaluating the project from a Strategic Niche Management perspective brings out interesting observations.

The primary aims of Strategic Niche Management include learning about the problems, needs and possibilities of a concept, building of actor networks, aligning the different interest and expectations of the involved actors to a common goal and fostering institutional adaptation (Kemp et al., 1998). The goals of the Hietaranta project are somewhat similar. It tries to develop a concept for ecological living in the countryside. Energy efficient single-family houses are a key part of this concept. The idea is that this concept could be applied in other municipalities in the future. In addition, a goal is to establish local business networks to promote business activity around energy efficiency and ecological living. Furthermore, all the goals of the project aim at making living in the countryside a more desirable alternative (Hietaranta, 2004a; 2004b; Savonen, 2005).

- The former head of the municipality of Tuusniemi Mr. Jussi Teittinen initiated the project. Naturally, the underlying idea was to attract families to the small municipality and support the local business life. Teittinen started to gather a network of different actors to the project. Mr Kimmo Lylykangas was recruited to join the project during a seminar. Lylykangas was authorised to manage the project to a large extent. In addition to designing the houses, he gathered actors and planned the marketing of the project.
- According to Lylykangas, the project received a considerable amount of EU Leader funding as well as funding from Tekes and Sisä-Savon Seutuyhtymä. In addition, the municipality of Tuusniemi invested in the project. The plots of Hietaranta are offered under market prices and the municipality invested some funds in marketing. The Ministry of Trade and Industry supports the building of the ground source heat pump network that will be built to the area. This provided a needed protected space for the project, which otherwise would probably not be feasible.
- The project brings together a variety of different actors from the producer and social actor side. This is important; in order to consider the needs and interests of the all the actor groups and learn what actions need to be considered in the commercialisation process. However, it seems that an important actor group was ignored to a certain extent. It came up in the interviews that the potential buyers were somewhat dissatisfied with the design of the Hietaranta houses. This was the case even though the area is designed for ordinary people and, thus, an image as an alternative residential area was avoided. The problem was also noted in the feedback gathered during the Heinola house fair in the summer of 2004.

Niche Management approach aims to bring together different actors to shape the experiment to make it match with the needs of the actors, as well as possible. Societal Embedding concentrates on an interactive learning process between three actor groups: producers, users and social actors. In Hietaranta an important actor group – end users (home builders) – was partly missing from the dialogue.

Consumer Expectations

It was again observed that sustainability alone is not a strong enough selling argument. It is natural that consumers emphasise other qualities. Consumers, or homebuilders in this case, are the most important actors when it comes to learning about the commercial potential of a product. They are the ones who finally decide whether an experiment becomes successful or not. In the case of Hietaranta, it would have been appropriate to involve future homebuilders from an earlier stage. Here, this is especially relevant, considering the location and overall popularity of the municipality. Doing this, the needs and preferences could have been considered initially. At this point, it is already much more difficult to involve homebuilders, as the project is already so far.

There was a considerable amount of interest in the plots, especially in the lakeside ones. The project and the area as a whole received positive feedback. The ecological side of the project was appreciated and acknowledged. However, in addition to the appearance of the houses, the prices were seen as a problem. The pricing problem characterises the current situation. The houses are priced considerably higher than so called normal ones. It was estimated by one of the interviewees that there is a premium of approximately 1000 euros per square meter compared to the average price in the region. According to the interviewees, this is the main reason to the apparent low demand of the houses. Due to the unexpected low demand, the original schedule to build the houses had to be postponed. Initially, the building of the houses was to be started in September 2004. However, during that time there was a certain amount of scepticism whether the houses will be built at all.

Other possibilities for building the houses are being considered. Instead of the initial idea of turnkey construction, a possibility for do-it-yourself building will probably be offered. This was one of the requests of the potential homebuilders. In addition, the possibility of using a smaller construction company to build the houses was being considered. According to the interviewees, this seemed necessary, in order to lower the cost of the buildings. A local construction SME was seen as an interesting alternative. Anyway, the energy performance requirements are still in force.

The other parties criticise the chosen constructor, for pricing the houses too high. Constructor on the other hand, used its normal pricing procedure. They do not consider Hietaranta as a special project. According to the interviews, contractor was persuaded to join the project, as nation-wide actors were needed.

Pricing

Pricing needs special attention when it comes to promoting the commercialisation of sustainable small-scale products, like energy efficient single-family houses. Pricing is one of the main obstacles to the wider acceptance of energy efficient single-family houses. An experiment aiming to establish practices to promote these types of solutions, needs to put special emphasis on the problems. If the price level of the houses is on par with the prices in the capital region, it is highly unlikely that there will be much demand.

Without a special commitment and thus lower pricing, it is difficult for a bigger construction company to reach the required price level. This is especially true considering the small-scale character of the project. Small-scale development experiments do not fulfil the growth needs of bigger companies (Christensen, 1997). In a project like Hietaranta, it is essential that all the main actors have a long-term perspective to the project. The expectations and visions of the big construction company involved in the project were not in line with the goals of the project, which made the situation difficult and formed an obstacle for further development.

Shared Vision

Mr. Jussi Teittinen, the former head of the Tuusniemi municipality started the project and succeeded in gathering a large variety of different actors to the project. According to Kemp et al. (1998), local authorities are especially suitable to engage in small-scale experiments. They are in a good position to form the needed networks around the experiment, as they have connections both to the business and public worlds. In the course of the project, Jussi Teittinen was, however, appointed to the municipality of Mäntyharju. This also meant that he resigned from managing the Hietaranta project. The situation is difficult, since Teittinen was the one with the original vision and the primus motor behind the project. The interviewees had the opinion that the retreat of Teittinen was problematic to the project. It is often difficult to take charge of a project launched by somebody else. In a situation where a big part of the project co-ordination takes place from Helsinki by Lylykangas, the Tuusniemi locals may feel distant to the whole project. This issue needs to be emphasised as the project moves on.

The project has, despite current problems, proven the feasibility of a municipality-based experiment to promote environmentally sustainable businesses. The connected R&D projects that focused on timber construction were considered successful. As an example, a low energy window and an energy efficient streetlight were further developed and a network for producers of special timber was established. A Platform-based application of an energy efficient single-family house was tested. The project had thus spin-off effects in the form of local business and developed concepts.

Conclusions

Considering the project from a Strategic Niche Management perspective, it seems clear that the project has already addressed many of its aims. Surely the problems, needs and possibilities of energy efficient single-family houses were tackled. Having a variety of actors present to work on the same project enabled the forming of networks. It is, however, yet to be seen whether these actors work together also in the future. At least the actors have a better possibility to engage in and develop similar projects. In a situation of increased demand of energy efficient solutions in the housing sector, the actors are better prepared to answer the demand. Especially the bigger nation-wide actors can take advantage of the experience in forming networks around energy efficient housing.

The project received a considerable amount of national as well as international interest (Savonen, 2005). The project was so far presented in different newspapers and magazines, on television, in different seminars and fairs. In addition to Finnish media, the project has received recognition at least in France and New Zealand. In the case of sustainable alternatives such as energy efficient single-family houses, achieving visibility is especially important. The municipality of Tuusniemi has also benefited from the project in terms of publicity.

The municipality-based model for implementing experiments to promote sustainable business seems suitable at least in the case of energy efficient housing. This is natural, since municipalities already have an important role, when it comes to building. As one of the interviewees put it, they can function as a bridge between private and public side and enable the implementation of small-scale experiments. Experiments such as Hietaranta are valuable in the transition process to sustainable business in the field of construction. However, more emphasis needs to be put on the execution in order to achieve full benefit from the project.

4.3.2 MotiVoittaja

The following analysis by Savonen (2005) concentrates on how MotiVoittaja competition succeeded in terms of promoting commercialisation of energy efficient single-family houses. The idea was to open up markets for overall competitive single-family houses with significantly lower energy consumption compared to the standards. In addition, emphasis was put on the consumption of electricity and water. Turnkey construction was also one of the requirements of the competition (Aho et al., 2001).

Business-Oriented Approach

Compared to the municipality-based Hietaranta project, the MotiVoittaja competition had a more business-oriented approach to promoting energy efficient single-family houses. Unlike Hietaranta, MotiVoittaja had only one goal: to promote the commercialisation of energy efficient single-family houses. The experiment brought together a variety of actors. In addition to Motiva and the participating companies, different social actors participated in the experiment: VTT Building and Transport, Tampere University of Technology and PRKK, a centre to promote single-family building, were among the participants. They set the competition requirements and evaluated the participating houses. A prestigious expert jury awarded eight houses of the 20 participants. The awarded firms are allowed to use the MotiVoittaja label in marketing these products. In addition to the social actors and producers, a group of interested homebuilders was gathered. Many of these committed to invest in an energy efficient MotiVoittaja house once the competition came to an end (Aho et al., 2001).

The experiment received funding from Tekes. In a way this provided the needed protection to the project. Without external funding the experiment would hardly have been possible or at least much more difficult to carry out (Motiva, 2004).

Problem of Commercialising Sustainable Business

The MotiVoittaja competition tackled the problem of commercialising sustainable business. By trying to establish the MotiVoittaja label into the single-family house market, the competition addressed one of the problems of energy efficient single-family houses. Turnkey construction and the MotiVoittaja label offer homebuilders an easy and straightforward solution to building an energy efficient single-family house. As noted by the interviewees (Savonen, 2005), ambiguous and complex information about energy efficiency makes it difficult for homebuilders to assess and judge these solutions. By offering a ready-made energy efficient solution, which is evaluated by experts, the MotiVoittaja houses allow an easy choice for sustainable housing.

In addition to lower energy consumption and sustainability, the competition emphasised other qualities of energy efficient single-family houses as well. These included comfort, healthy living environment in the form of good indoor air quality, applicability and living costs (Motiva, 2004). This was important considering the needs and preferences of homebuilders.

According to the interviewed participants (Savonen, 2005), the motives to join the competition were mostly business-based. The participants saw a future in energy efficient housing. They considered it as an investment to the future. Furthermore, it was natural for many of them, as they had already previously put emphasis on energy issues. It is presumable that firms interested in this type of competition already have a certain amount of experience from and interest in energy efficiency. Among the motives a desire to learn more and willingness to demonstrate own expertise were mentioned.

Even though the demand for the MotiVoittaja houses has been modest so far, the interviewees were cautiously satisfied with the competition. Eight new energy efficient single-family house alternatives were made available to the market and the experiment achieved visibility for a certain amount of time. The interviewed participants were also satisfied with the increased expertise in energy efficiency (Savonen, 2005). They felt more prepared to offer energy efficient solutions to their customers and answer their questions. One interviewee, however, was disappointed with the implementation and the basis of the competition. He found that the competition focused somewhat on wrong issues.

Missing After-Care (in lack of funding)

The project ended when the winners were chosen. They are allowed to use the MotiVoittaja label in their marketing. The right to use the label can in addition be granted in retrospect, if the competition requirements are met. After the competition, the winners did not invest much in advertising their MotiVoittaja models. The participants had hoped that these houses would have been promoted also after the competition (Mikkola & Riihimäki, 2002). Most of the participating companies are small and have limited resources to invest in marketing. Motiva admits that it could have done more in following through the project. It came up in the interviews that additional effort to promote the houses would have been needed. However, this was simply not possible from Motiva's side, as they did not have additional funds for the project. The promising experiment was left without proper after-care. One or two active participants bring forth the MotiVoittaja label in their marketing. One participant has been successful with its MotiVoittaja house. The experiment would have clearly benefited from a marketing campaign after competition.

Conclusions

As discussed (Savonen, 2005), the current low demand for energy efficient houses makes the supply difficult, as the volumes are low. This is especially true, due to the small size of most of the producer companies. It was mentioned in the interviews that scale is needed in order to bring down the costs of these houses and thus support the demand. This would call for co-operation and networking. The MotiVoittaja competition did not directly address this. Moreover, a competition-based experiment is not necessarily the best way to promote small-scale sustainable business.

Even if participating companies were cautiously satisfied with the competition, considering the goals of the competition and the market situation of energy efficient single-family houses, the way the MotiVoittaja was carried out does not quite seem to acknowledge the principles of Strategic Niche Management, or Societal Embedding. The competition did bring together actors from the producer, homebuilder and social actor side. However, not much interaction or learning took place between the actor groups. The competition did not manage to tackle the most important problems that energy efficient single-family housing faces. It succeeded in getting eight products to the market, but this did not bring much change, as the main obstacles were not addressed.

5. Actor Networks

5.1 Actor Network for Energy Efficient Single Family House

Key actors related to energy efficient single-family houses can be divided into three groups according to the tripartite model presented by Väyrynen, Kivisaari and Lovio (2002). Actors included in Figure 6 are chosen based on the interviews and discussions that took place during the research of Savonen (2005).

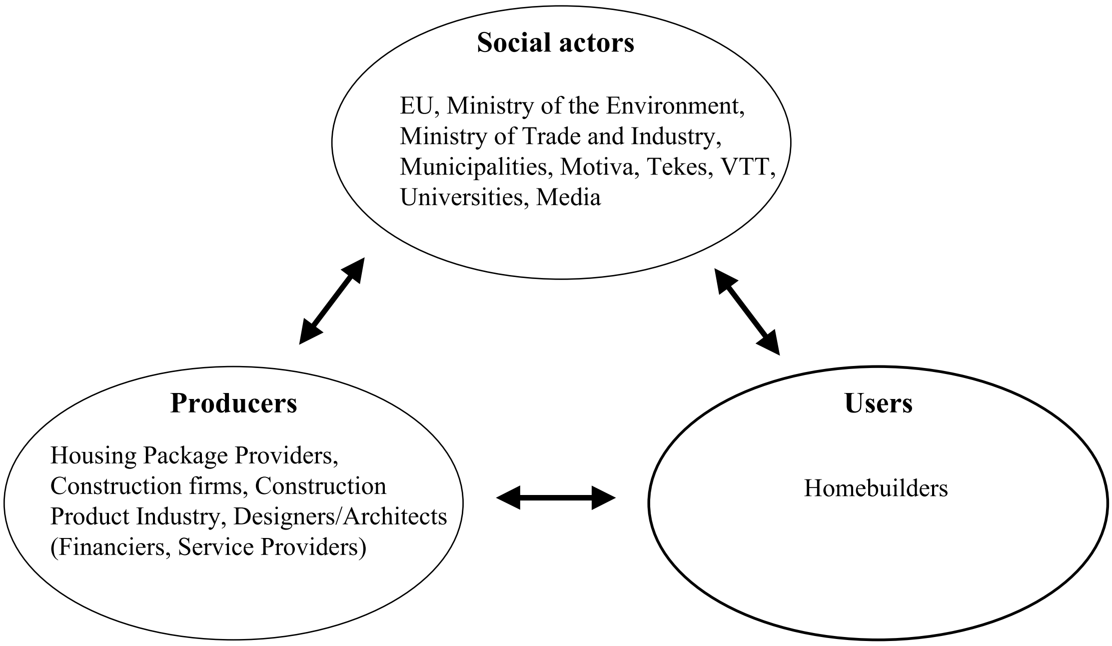

Figure 6. Identified key actor groups in context of energy efficient single-family houses (Savonen, 2005).

Merely identifying the actors does not get us further. Problems that hinder the commercialisation of energy efficient single-family houses need to be discussed. Identifying the problems of commercialising energy efficient single-family houses was one of the three main issues emphasised in the interviews (Savonen, 2005). In addition to the interviews, following conclusion draw on findings in earlier VTT studies and literature.

5.2 Network Interests

A business model links activities, actors and resources together, within and between stakeholders in buyer-seller relationships. Different stakeholders have different interests. In general, there is an obvious risk for conflict of interests. A challenge remains how to create service concepts, which support different stakeholders' business strategies. In order to create service concepts for win-win-win situations, all stakeholder interests should at least be partly in line with the concept. In case there is a common concept and a true value network, conflict of interests should be avoidable. If a stakeholder is part of a true value network, there are both B2B and B2C issues involved and they should not stand in conflict with each other. On the contrary, the good B2B supports B2C and vice versa (Nykänen et al., 2004). This means adapting your own business interests to the product & service concept instead of sub-optimizing your own business only. The idea of a user centered value network is visualised in Figure 7.

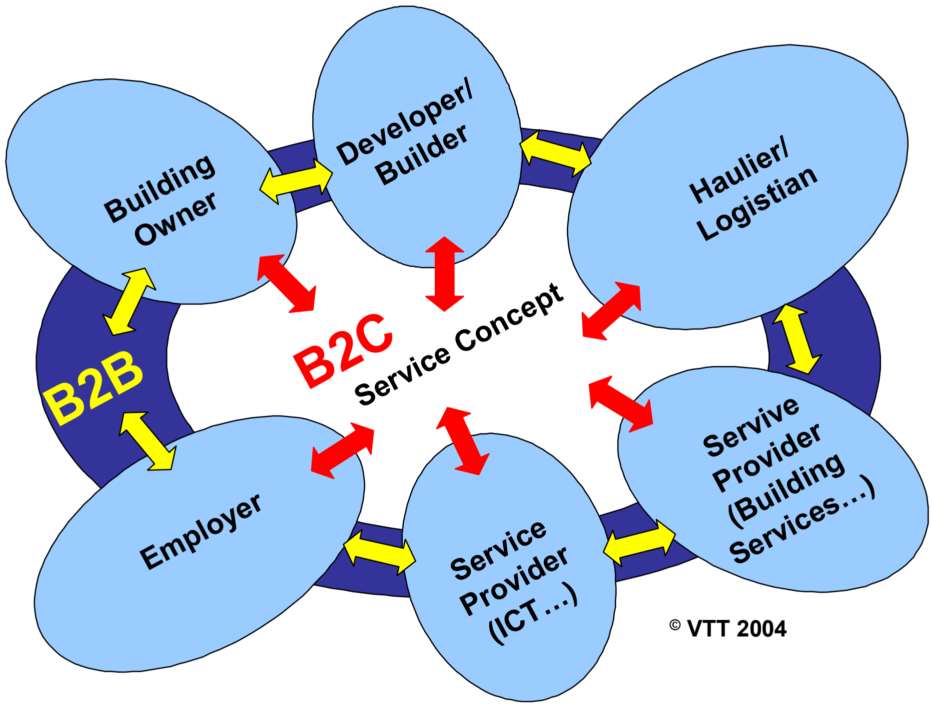

Figure 7. Open Product & Service Concept Based on Value Network (Nykänen et al., 2004).

The challenge is to create new service concepts, which support different stakeholders' businesses. The capability of creating good, sustainable business out of service seems to be missing in general. Well-defined, well-managed and open value networks with joint creation of value require a new way of thinking.

5.2.1 Users

At present, homebuilders are seen as the most important user group. Even though other user groups may be identified, they are rather irrelevant as single-family houses are considered. Homebuilders are naturally in a central role when it comes to commercialising energy efficient single-family houses, as the demand for such building largely derives from them.

Living in a single-family house is something most Finns prefer. Studies show that over 80 per cent of Finns share this opinion. However, especially in the capital region it is usually only possible for wealthier people. Living in a single-family house is a conscious choice. A single-family house is often the house of dreams and something that is not easily abandoned (Mikkola, 2004).

The age profile of single-family house dwellers is somewhat high. Only a small number of them is under 30 years old. However, recently the age range has widened, as increasingly younger and also older people have started to build single-family houses. Typically, single-family houses attract families with more children than the average. The occupational background of single-family house builders varies considerably. They can be higher level managers as well as normal blue-collar workers. Under one fifth, though, are professionals in construction and roughly 40 per cent have prior experience from building. Thus, almost 50 per cent are inexperienced in terms of building and construction. This is a sign of certain lack of information and know-how, and partly explains the popularity of prefabricated single family-houses and turnkey construction (Mikkola, 2004).

Mikkola & Riihimäki (2002) have studied the familiarity of energy-efficient houses among homebuilders. Even though there have every now and then been articles about energy efficient building in different media, the familiarity of such building is rather low. From the respondents 60 per cent had either never heard of energy efficient single-family houses or considered their knowledge of them inadequate.

5.2.2 Social Actors

Social actors have an important role when it comes to promoting environmentally sustainable businesses.

Government

As an example, the Finnish government promotes the use of energy efficient products in its programme. *(The Government Programme of Prime Minister Vanhanen's Government 2003: 35, 37.)*

> *"…The structure of taxation will be revised so as to promote sustainable development. Ecological tax reforms will reduce the use of non-renewable natural resources and prevent environmental damage. At the same time, the*

recycling and ecological efficiency of products, their consumption and energy use will be promoted. Ways of cutting subsidies detrimental to the environment and to sustainable development will be explored...."

"...Finland will play an active role in preparations for an international framework programme for sustainable production and consumption. The aim is to increase efficiency in the use of materials and energy throughout the life cycle of a product. Production and expertise based on environmental technology will be promoted..."

"...An indicative and operational programme will be drawn up for the allocation of research and development funding and development of the innovation environment. Funding will be allocated to areas such as branding, commercialization, and research and development in the service and new technology sectors, and to know-how and innovation that support sustainable consumption and production..."

European Union

The European Union has a strong incentive to emphasise energy efficiency. Only the Kyoto Protocol sets heavy requirements for cutting the carbon dioxide emissions in the member states. In addition to the environmentally oriented issues, the motivations include e.g. the desire to influence the global energy market and hence to secure the supply of energy through demand management. As the building sector is responsible for 40 per cent of the total energy consumption in the Community area, improving energy performance in this field is vital in reaching the set Kyoto goals. Energy efficient single-family houses are one way to promote energy efficiency in the building sector. In 2002, the European Parliament and the Council of the European Union approved a directive to improve the energy performance of buildings. This has effects on single-family houses as well. The following paragraphs present the new directive (European Union, 2004; EC Directive 2002/91/EC).

The EC Directive on the Energy Efficiency of Buildings

The objective of the directive is in promoting the improvement of the energy performance of buildings within the European Union. It takes into consideration local conditions as well as cost-effectiveness. The main requirements of the directive relate to the application of minimum requirements on the energy performance of new buildings. This requirement also applies to large existing buildings that are to be renovated. The member states have to apply a methodology of calculation of the energy performance to be able to meet the requirement in an objective manner. Another major requirement is the energy certification of buildings, which focuses on the problem of inadequate information. In addition, the directive lays down requirements on regular inspections of heating boilers and air-conditioning systems (EC Directive 2002/91/EC).

Member states have to ensure that the minimum energy performance requirements for buildings are enforced and that they are based on the mentioned methodology. The requirements, however, allow member states to differentiate between new and existing buildings and take into account local conditions and the function and age of the building. These energy requirements have to be reviewed and updated regularly to reflect the development of the construction industry. Certain types of buildings are exempted from the requirements (EC Directive 2002/91/EC).

Energy certificates and labels have so far been widely used in promoting energy efficiency in household appliances and in the construction product industry. Properly implemented energy labelling policies have proven successful. However, applying them to consider whole buildings is rare (Wiel & McMahon, 2003; Mahlia et al., 2002; Colombier & Menanteau, 1997)

The directive introduces a certificate for the energy performance of buildings. According to the directive, every time when buildings are constructed, sold or rented out, a certificate has to be made available. The certificate is valid for ten years at a time. This certification has to include reference values such as current legal standards and benchmarks to make sure that consumers have a possibility to compare and evaluate the energy performance of the building. In addition, the certificate has to include recommendations for cost-effective energy efficiency improvements. The certificate provides consumers with information allowing them to put more emphasis on the energy efficiency as a selection criterion (EC Directive 2002/91/EC).

Furthermore, the directive includes an article, which requires member states to implement measures to establish regular inspections of heating boilers of certain output fired by non-renewable liquid or solid fuel. Besides heating boilers, the requirement for inspection covers air-conditioning systems. The purpose of the inspections is to reduce energy consumption and unnecessary carbon dioxide emissions. Consumers should be provided with advice on possible improvement or replacement of the systems and on alternative solutions (EC Directive 2002/91/EC).

Qualified experts should carry out the certification procedure and the inspections in an independent manner. This puts pressure on the member states, as the number of these experts is limited compared to amount of expected work. The member states have to amend their legislation, in order it to comply with the directive by early 2006. If the member states have difficulties due to a lack of qualified inspectors, an additional period of three years can be granted. The additional period of three years relates, however, only to the implementation of the certificate and to the inspections of boilers and air-conditioning systems. In addition, resorting to the additional period requires appropriate justification and a schedule how to fully meet the directive requirements (EC Directive 2002/91/EC).

Ministries

The Finnish Ministry of the Environment and the Ministry of Trade and Industry are the two most important ministries when it comes to promoting sustainable business in the field of building and construction. The Ministry of the Environment is responsible for issues related to housing, land use and construction, whereas the responsibilities of the Ministry of Trade and Industry include energy, technology and industrial policy related issues. The activities of these two ministries touch upon commercialisation of energy efficient single-family houses. The ministries fund various organisations and implement EC directives into the Finnish legislation. The Ministry of the Environment, for example, is responsible for implementing the EC directive on the energy performance of buildings. In addition, it is responsible for the Finnish Building Code. The Building Code was revised in 2003 (Ministry of the Environment, 2004; Ministry of Trade and Industry, 2004).

The Finnish Building Code

Parallel to the directive, the Ministry of the Environment prepared and introduced revisions to the Finnish Building Code. The new regulations came into force in 1.10.2003 and focus on improving thermal insulation, ventilation and indoor air quality. The aim is to decrease energy consumption by 25–30 per cent compared to the previous standards. The preparation of the new Building Code was already far when the new EU directive was announced, which explains the introduction of the Code only a few years before another large legislature change (Ministry of the Environment, 2004).

Motiva

Founded in 1993 Motiva is an impartial governmental service organisation that promotes renewable energy sources and efficient use of energy. In 2000, it became a limited company owned by the Finnish State. Motiva focuses on producing, refining and spreading information. In addition, it develops methods and promotes the introduction of renewable energy sources. Motiva carries out government’s decisions on conservation of energy and promotion of renewable energy sources. As one of its main principles, Motiva tries to operate close to the markets of energy use. It tries to combine resources and focuses on networks in its operations (Toimintakatsaus, 2003; Motiva Oy, 2004).

Tekes

Tekes is the National Technology Agency of Finland. It is the main public financing and expert organisation for research and technological development in Finland. Its primary targets for financing include industrial R&D projects as well as projects in research institutes. Tekes especially emphasises innovative, risk-intensive projects.

The underlying objective of Tekes is in promoting the competitiveness of Finnish industry and the service sector. It aims to achieve this by assisting in the creation of technology and technological expertise. Diversifying production structures, increasing production and exports and creating a foundation for employment and social wellbeing are issues that Tekes aims at in its operations. Tekes receives its funding annually from the Ministry of Trade and Industry (Tekes, 2004).

VTT

VTT, the Technical Research Centre of Finland is a contract research organisation providing a variety of technology and applied research services for its clients. These include among others private companies, institutions and the public sector. VTT's activities are partly funded by the state, but a big part of its operations are based on funds generated by operations. With its 2800 employees, 5000 customers and revenue of 210 million Euros VTT is among the biggest research institutes in northern Europe (VTT, 2004).

In its activities and strategy VTT emphasises sustainability and innovativeness. VTT has been actively developing technology and solutions for energy efficient single-family houses and has taken part in various projects to commercialise this knowledge.

Universities

Universities, and to a certain extent also polytechnics and vocational schools, have a key part in providing basic research and education in the building and housing sectors. In the field of building energy efficiency, Tampere University of Technology has been especially active.

As most of the people engaged in building are influenced by the education provided in different schools and universities, the impacts of education are clear. When it comes to promoting change in the patterns of behaviour and mindsets, education plays a paramount long-term role.

Municipalities

Municipalities have an important part in steering building and land use. The some 450 Finnish municipalities take charge of land use planning and building guidance within their region. Doing this, they have to comply with the land use and building act. According to the first chapter and section of the land use and building act, the objective of the act is to ensure a favourable living environment and promote ecologically, economically, socially and culturally sustainable development. In addition, municipalities have interests in promoting business and employment within the region (Land Use and Building Act, 1999).

Building Guidance

As to building guidance, one of the objectives is to promote building that is based on approaches that have sustainable and economical life-cycle properties, are socially and economically viable and create and maintain cultural values. Building guidance is mainly implemented through the Finnish Building Code and building ordinances[1] issued by municipalities. The regulations in the Building Code are binding.

All municipalities have to have a building ordinance. The building ordinance issues regulations that are based on local conditions and are necessary for organised and appropriate building. The building ordinance has to consider cultural, ecological as well as scenic values. The regulations in the building ordinance may concern a variety of issues. An interesting issue is the possibility to regulate the method of construction. This means that municipalities are able to set conditions regarding e.g. the energy efficiency of buildings that exceeds the requirements of the Finnish building code. This was the case in Hietaranta, one of the two case examples looked at in this study (Land Use and Building Act, 1999).

Land Use

Land use is governed by the Council of State. It decides upon national land use objectives. On a regional level, the national objectives are taken into account when preparing the regional scheme, regional plan and the regional development programme. The regional plan sets out the guidelines of land use and municipality structure. The

[1] Rakennusjärjestys in Finnish

local master plan provides general guidance regarding the municipality structure and land use. A local master plan may also be used to guide land use and building in a specific area. In addition, the local detailed plan is used for the purpose of detailed organisation of land use, building and development. The local detailed plan is also used for steering purposes. The local master plan and detailed plans offer the local authorities a possibility to promote e.g. energy efficient housing within their respective areas (Land Use and Building Act, 1999).

5.2.3 Producers

The third actor group, producers, includes actors that are in the end responsible for providing energy efficient single-family houses to the users. They are the group that has the business interest and in practice face the problems of conducting environmentally sustainable business. The providers of housing packages form the most important producer group, as the majority of single-family houses in Finland are sold as packages through these firms. Construction firms are also important, considering that a part of the Finnish single-family houses are still built traditionally. In addition, construction firms have a role in setting up the houses. Energy efficient single-family houses involve, and may generate business for, the construction product industry as well as architects and designers among others.

Providers of Prefabricated Houses

Firms providing prefabricated houses in Finland number up to 300. The three biggest players in the wood sector include Finndomo Oy, PRT Forest and Harjavalta Oy. The biggest brands are Kastelli, Jukka, Omatalo and Vaaja, respectively. The biggest player in the concrete side is H+H Siporex Oy with its Jämerä houses made of aerated concrete Siporex. Jämerä has grown in popularity during the recent years. (Riihimäki & Lehtinen, 2000)

Approximately 50 per cent of prefabricated houses are sold via an agent or a salesman. The biggest firms also have sales offices to conduct sales from. Sales offices are responsible for roughly one fourth of the total sales. Sales straight from the factory account for around 10 per cent. Retail stores and chains, such as K-Rauta and Starkki, sell 15 per cent of prefabricated single-family houses (Riihimäki & Lehtinen 2000).

The market for prefabricated single-family houses has grown steadily since the early 90’s. For the year 2004, the market for prefabricated single-family houses is expected to reach 450 Million euros.

5.3 Innovation in Networks

A consideration of innovation generally in construction and the broad features of the actor networks were described above. We will now highlight the challenge of change in such context. Innovation in networks, in this context, is considered as an example of "systemic innovation".

It is first important to recognise the structure of the construction industry in general and to appreciate that talk of "innovation" actually needs to consider the constraints facing small and medium sized enterprises (SMEs), who represent over 95% of the total contruction industry and home-building in particular (Wharton & Payne, 2003). In addition, the fact that most construction activity and actors relate to their immediate local environment, (in terms of market, suppliers, finance), means that there are often not the necessary framework conditions to facilitate changes in practice or development of new market offerings (Dick & Payne, 2005)

Innovation in construction has three main outcomes or forms (Commission of the European Communities 2000):

- technologically new/improved buildings and physical infrastructures
- technologically new/improved construction processes
- non-technological improvements in the organisation of construction.

Buildings and infrastructures may exhibit examples of technological product, or technological process innovation – all of which may increase the production (or consumption) possibilities of the user. Alternatively, strategic alliances between construction firms, partnering arrangements between members of a construction team, framework agreements between construction firms and building merchants, and private-finance initiatives are all examples of non-technological process innovation. These innovations allow a better allocation and use of resources.

Construction is different from other production systems in a number of important respects: the products are fixed in space; i.e. they are produced or assembled at the point of consumption; the products are generally commissioned or made to order; each product is produced for a particular client – this means that they vary in scale, technical complexity, and expected longevity; and the project team is a temporary alliance between independent organisations. These features mean that firstly, construction involves the solution of a number of unique site-related and client-related problems and secondly, that the degree of inter-organisational negotiation is higher than in normal manufacturing processes. We should also remember that construction also takes place within a specific socio-political context (Chapter 5.2.2). This means that the production possibilities and modes of inter- and intra-organisational negotiation are affected by specific codes, regulations and procedures (e.g. urban planning, professional codes of conduct, building materials regulations), which are intended to address public issues such as health, safety and the environment. Together these features of construction help to explain the complex organisation of construction and affect the process of innovation in construction and its outcomes.

Slaughter (1988) describes five types of technological construction innovation: incremental, radical, modular, architectural and systemic). Incremental innovation in construction refers to a small change in the product/process that has negligible interaction with other components of the product or parts of the construction process. In contrast, radical innovation in construction refers to technological breakthroughs that radically change the character of construction products or processes. Modular innovation is similar to incremental innovation and refers to significant technological changes within the component that have little or no impact on other components and systems. Architectural innovation refers to a technological change in a component that has a major impact on other components and systems. This means that the process of innovation is relatively complex; it will involve interaction between the developers and other construction actors regarding changes and modifications to other components and systems, and the appropriate development of the technology itself. Finally, system innovation involves the integration of multiple independent innovations and actors in the total context, providing technologically new or improved facilities.

It is worth noting that within the SME building firms, 54% have fewer than 10 employees, many of whom are either petty capitalist or simple commodity producers. These firms are particular reluctant and unable to innovate to a great extent, and thus particularly resistant to business improvement measures (Ball, 1988). This aversion to risky innovation has self-reinforcing and knock-on effects. It suppresses the demand for innovation and this in turn reduces the demand for RTD and other ‘pre-conditions’ for advanced project-based innovation. More to the point, it affects the direction of technological and organisational innovation, moving it toward modular technology and pre-fabrication (mass production, and bespoke), and away from radical and systemic innovations. And this has an impact on the activities and capabilities of SMEs further up the supply-chain.

System innovation may not be uncommon in construction, since its product and the process must be configured to unique site conditions and client-demands. "Systemic innovation" is a form similar to system innovation – understood more simply, as product and process innovations that require multiple firms to change their processes in a coordinated fashion (Taylor & Levitt 2004). However, the occurrence and diffusion of such innovations is still an emerging topic of research. As such, there is a limited amount of evidence to guide or formulate a "best approach" to innovation in networks – as it applies within the scope of this paper, – only to acknowledge that as "systemic innovation", the innovation in actor networks described in previous sections is not yet a straightforward procedure!

5.4 Matching Demand and Supply

5.4.1 Demand

VTT's market study on potential home builders that are willing to build an energy-efficient home showed that the demand does not meet the supply. Roughly 50% of the builders considered building energy-efficiently, but only 10% built an energy efficient home, Mikkola & Riihimäki (2002). The main reason for building typical was the lack of appealing possibilities. However, business opportunities for energy efficient single-family houses do exist. Energy directive and energy labeling of houses will inevitably change the market situation. In order to make use of these opportunities, the current locked-in patterns that keep these alternatives from receiving wider acceptance need to be changed. In the case of energy efficient single-family houses, the lock-in situation stems from a set of interrelated rules that together prevent the present state from changing (Savonen, 2005).

5.4.2 Supply / Delivery

To be able to achieve a wider market position of eco-efficient construction, new kind networking is required. Savonen (2005) and Kivisaari (2004) show that there are possible ways through narrow market niches to market acceptance. Niche management is based on technology demonstration to make the technology well-known. As the market success increases, the development of the concept can be promoted. The success also requires socio-economic acceptance. There are two possible ways:

- The product (whole building) is allocated to a specific market segment. The producer needs to create a differentiation strategy to serve this market segment.
- The product is allocated to a network operation. The production network has to be able to manage the whole building approach, and to create a new production culture for construction.

The segments of the Finnish housing market have not been defined. It has been anticipated that the demand for eco-efficient housing grows from academic families with children, but there is no clear evidence on that. It is also quite uncertain that market orientation based on market segments would change the processes and market situation to enable the market penetration. The notion of socio-economic regime can be used to conceptualize the situation.

The development of the two case housing areas (Chapters 3.1.1 and 3.1.2) is carried out as a network operation. In Tuusniemi, the wide publicity the project immediately gained increased the interest in the housing area. Before any single building was erected, the population of the municipality turned growing, thus helping the municipality with its main problem of depopulation. The project also supported local building products industry. Manufacturing of new timber products and low-energy windows grew from the development carried out. If these are weak signals of increased interest on eco-efficient housing, the concept itself can be expected to benefit from the growing interest.

6. Conclusions

Buildings and particularly their use have a significant environmental impact and thus more sustainable solutions are gravely needed. It is estimated that buildings are responsible for 34 per cent of the total Finnish energy consumption. On the level of the European Union the figure even exceeds 40 per cent. Thus, a considerable savings potential exist. The energy consumption of buildings is something that needs emphasis, if Finland wants to meet its target in reducing carbon dioxide emissions and thus fighting climate change. Energy saving is our biggest unexploited source of energy.

There is not a single barrier that keeps energy-efficient housing from taking off. A whole range of issues has to be considered. As there is little research available on the business possibilities of energy efficient single-family houses, the goal of this study is to form a big picture and thus serve as a basis for further research. Earlier research findings on energy efficient building, conducted by VTT, are now complemented by this study. Our focus was on energy efficient single-family houses:

- Demand and supply of niche products (energy efficient single-family houses)
- Drivers for business potential and opportunities
- Management of transition to environmentally sustainable business.

6.1 Demand and Supply of Niche Products

6.1.1 Consumers with Needs and Preferences

In many cases, environmental friendliness and sustainability are not the foremost drivers of consumer behaviour. Consumer needs and preferences concentrate more on down to earth and everyday issues such as comfort, appearance, usability and safety.

Turnkey construction is becoming more and more popular in Finland. There are many reasons behind its popularity. Firstly, the generally higher standard of living allows this type of construction, as people have more money to be spent on housing. Secondly, the number of people with skills to set up a house is getting smaller and smaller. A clear sign of these two is the fact that turnkey construction is most popular in Uusimaa province, close to the capital region, where people in general are not considered experienced in doing construction work. Or people do not have time for that! Uusimaa province is also the most important region for prefabricated houses in general.

It is estimated that the price on electricity will increase by 15 to 20 percent (or even more), due to the carbon dioxide emission trade agreed on in the Kyoto Protocol. Along with the increase, it can be expected that energy issues become more important to homebuilders and to consumers in general. Already now, 1/3 of homebuilders consider the expected resale value as the most important feature of a new house.

6.1.2 Technology Solutions

The most cost-effective way to improve energy efficiency is to concentrate on new construction. In an energy efficient single-family house, life cycle costs are 10 to 30 per cent lower compared to a regular house, depending on cycle length, need for finance and price development of energy. Even if the initial investment cost is from zero to five per cent higher, the payback period of an energy efficient house is under ten years. However, the existing building stock is the real challenge in terms of energy-efficiency; technologies developed for new construction have applications in renovation as well.

6.2 Drivers for Business Potential and Opportunities

Despite the efforts made towards sustainability, the actual results are small-scale. The attempts to introduce sustainability have mostly been on a grass-root level. Results achieved are, however, promising. It is crucial to recognise why these practices remain marginal and without established business around them.

It is difficult for issues that differ from the existing rules to achieve acceptance. Environmentally sustainable business and thereby energy efficient single-family houses are an example of this.

Commercialisation of energy efficient single-family houses comes close to the problems of commercialising any environmentally sustainable products. They come into conflict with the current industry structures, organisations and institutions and with the general behaviour of different, related actors. Formal rules may change quickly through decision making, but informal rules embodied for example in customs and traditions are more deeply rooted. Evolved practices govern the every-day operations of the industry and are often deeply rooted and hard to change.

Technological regimes are a widely discussed topic. They focus on the technology itself without putting much emphasis on the surrounding environment. In this situation, special measures are needed.

6.2.1 Tensions and Mismatch

Radical novelties have only minor chances to break out from the niche status, as long as regimes are stable. Tensions and mismatch, however, may create “windows of opportunity” for the breakthrough of more radical novelties.

Changing user preferences may create tensions, if the established regime cannot meet them. User preferences may change for a number of reasons. These include cultural changes, changes in relative prices and policy measures, such as taxes. Increasing energy prices may change user preferences towards more energy efficient alternatives in the housing industry. Negative externalities are also a possible source of tensions and mismatch. These can for example be environmental impacts, health risks and safety concerns. Actors inside the regime often underestimate the negative externalities. This means that the problems usually have to be pointed out by outsiders.

6.2.2 Information Asymmetry

Scores of engineering and behavioural studies provide evidence that numerous market imperfections exist in the markets related to energy. Insufficient and incorrect information is a major cause for inefficiencies. In efficient markets, free and perfect information is assumed. However, in reality information is usually difficult and expensive to obtain. This is especially true in complex situations. A distinct form of insufficient and imperfect information emerges when two parties have different levels of information. This problem of asymmetric information is extremely common in real world markets making inefficient decisions the rule rather than the exception. Producers are most likely better informed about the characteristics and the performance of the products than buyers are. It is difficult to estimate product performance prior to sale.

The providers of housing packages form the most important producer group, as the majority of single-family houses in Finland are sold as packages through these firms. Construction firms are also important considering that a part of the Finnish single-family houses are still built traditionally. In addition, construction firms have a role in setting up the houses. Energy efficient single-family houses involve and may generate business for the construction product industry as well as architects and designers among others.

6.2.3 Energy Performance Directive

The energy performance directive is expected to have an effect both on the demand and supply side. Especially the included energy performance certificate has been seen as a trigger for change.

The certificate is likely to achieve wide attention once it will be introduced. The number of specialists needed to carry out the certification process is considerable.

The supply side effects of the energy performance certificate are expected to be of wide range. The certificate may contribute to eliminating worse performing houses from the market and put a pressure to the producers to concentrate on the more efficient alternatives. (The certificate might have a similar kind of effect as the energy certificate for electric household appliances: practically all the worst rated appliances disappeared from the market shortly after the energy certificate for such appliances was taken in use.)

6.3 Management of Transition to Environmentally Sustainable Business

The above discussed issues are among the most important to cause tension and misalignment in the socio-technical regime. By doing this, they open up the regime for alternatives that differ from the system. Herein lie the business opportunities of energy efficient single-family houses (Figure 8). In this situation "niche products" such as energy efficient single-family houses have an opportunity to achieve wider acceptance. The role of local authorities as possible "niche managers" is gradually getting more consideration in many municipalities.

To achieve wider acceptance, a transition towards sustainability in the society is needed. This transition cannot be managed in the traditional manner of controlling and supervising. However, it can be managed in terms of influencing and adjusting. This means that the pace and direction of the transition can be influenced. In practise this means creating a right climate for innovations and taking right initiatives at the right moment. Transition management attempts to bring about the needed structural change in a stepwise manner. Structural change is needed in order to tackle the institutionalised structures that hinder the wider acceptance and development of environmentally sustainable business. Experiments with alternatives to the existing system have an important role in the transition process, as they provide the seeds for change.

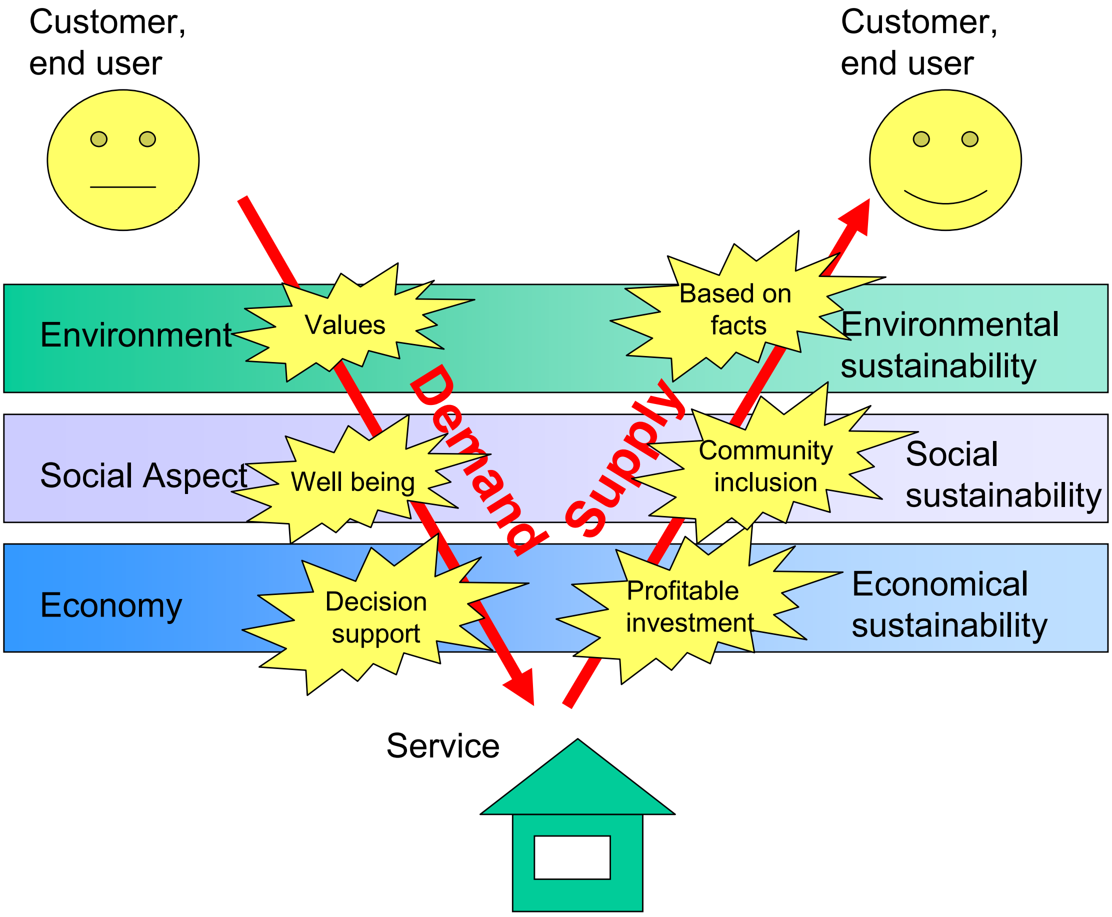

Figure 8. Drivers for sustainable housing.

6.4 Concluding Remarks

In the last 15–20 years, a number of projects have been carried out aiming at energy-efficient and environmentally friendly housing. There is a wide range of technologies and concepts that have been tested in monitoring projects. Technological possibilities to reduce a building's energy consumption have been available for a long time. Also, the costs of energy efficiency have been proved to be almost negligible. Despite of the existing vast amount of information, no clear market change has happened. We have identified three major trends paving the way towards Business from Sustainability,

1. The basic assumption is that in future only eco-efficient solutions will be acceptable in the aftermarket. Single-family housing represents the major demand for housing and primary market area for eco-efficient construction. This will bring improvements to the value thinking in construction through the following operational impacts:

- Market conditions of products and services improve through better user/owner requirement management.
- Improved life-cycle properties of new single-family houses are qualified according to commonly accepted criteria (e.g., energy classification, labelling procedures).
- Life-cycle costs, investment costs and value thinking are evenly important factors in decision making.

2. Sustainable development and development of knowledge society have an impact on production, supply chains, delivery modes of buildings, and in-use services. Information services offer a platform for more accurate user (owner) participation, as well as a media for verification of user benefits. Internet is already the primary information source in pre-construction phase.

3. Performance based building places user and owner needs in the focus. The methodology provides practical means for assessing benefits of new technologies. Performance approach requires an integrated and transparent procurement process and is therefore closely connected to the development of knowledge society. The process of change can be supported by the following measures:

- Increased independent and impartial information on sustainable building: Overcoming contradicting information produced by companies who have their own interest in the market.
- Objective information for builders: Objective, builder oriented information on user benefits and cost effects of eco-efficiency.
- Social acceptance: Evaluation of demand on eco-efficient housing and living and social acceptance of model buildings.
- New eco-efficient housing concepts (e.g., model houses): Open concepts especially for SME's to be utilised in network operation.
- New procurement procedures: Integrated design process, performance based tendering, commissioning.

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Appendix A: Conducted Interviews

23.9.2004 Mr. Topi Suutari, Rautalammin Rakennus Oy

23.9.2004 Mr. Kari Raatikainen, NCC Kuopio

24.9.2004 Mr. Jukka Pitkänen, City of Kuopio, Business Development Department

24.9.2004 Mr. Martti Kähkönen, Municipality of Tuusniemi

6.10.2004 Mr. Juhani Malkamäki, Lämpöässä Oy

6.10.2004 Mr. Antti Ahonen, Tekes

8.10.2004 Mrs. Maarit Haakana, Ministry of the Environment

8.10.2004 Mr. Pekka Kalliomäki, Ministry of the Environment

8.10.2004 Mr. Ilari Aho, Motiva Oy

12.10.2004 Mr. Ari Piiroinen, Uudenmaan Rakennuslinja Oy

12.10.2004 Mr. Esko Piispanen, Vaajatalot Representative

18.10.2004 Mr. Kimmo Lylykangas, Arkkitehtuuritoimisto Kimmo Lylykangas

18.10.2004 Mr. Arto Aalto, H+H Siporex Oy

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Business from Sustainability
Drivers for Energy Efficient Housing

Abstract
Why is the market interest in energy efficient houses still low? Is it because consumers do not want to pay a higher initial investment cost? Are consumers interested or aware of energy related issues? Are the constructors unwilling to push these products to the market in a situation where price seems to be the only source of competitive advantage?

In the last 15–20 years, a number of projects have been carried out aiming at energy-efficient and environmentally friendly housing. There is a wide range of technologies and concepts that have been tested in monitoring projects. Technological possibilities to reduce a building's energy consumption have been available for a long time. Also, the costs of energy efficiency have been proved to be almost negligible. Despite the existing vast amount of information, no clear market change has happened.

The scope of a low-energy building is to achieve comfortable, healthy and safe indoor climate. The construction is based on simple and well performing materials, structures and building services systems that fulfil the requirements set for the building. Energy efficient housing would offer many individual level benefits, and in order to assess them one should have a long-term perspective. As heating accounts for a majority of the life cycle costs of a house, energy efficiency means substantial cost savings. However, up to now most homebuilders are not focused on energy efficiency. There is not a single barrier that keeps energy-efficient housing from taking off. A whole range of issues has to be considered. Commercialisation of energy efficient single-family houses comes close to the problems of commercialising any environmentally sustainable product. They come in conflict with the current industry structures, organisations and institutions and with the general behaviour of different, related actors. In this situation, special measures are needed to promote commercialisation. The transition to sustainability needs to be managed.

Earlier research findings on energy efficient building, conducted by VTT, are now complemented by this study. We have identified major trends paving the way towards business from sustainability. Our focus was on three strategic issues:

1. Demand and supply of niche products, i.e. energy efficient single-family houses;
2. Drivers for business potential and opportunities;
3. Management of transition to environmentally sustainable business.

Keywords
single family houses, energy efficiency, energy consumption, energy conservation, environmentally sustainable business, eco-efficient construction, regional construction, strategic niche management, life-cycle costs, business opportunities

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