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**Case Study “Energy Efficiency in Buildings”**



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# 1 Introduction

The issue of economic growth has been a topic widely debated within the environmental movement. Part of this debated was in the 70s fuelled by the study *The limits to growth* (Meadows et al, 1972) ordered by the Club of Rome, with its gloomy scenarios following a neo-malthusian tradition that population and economic growth would reach its limits and resulting in a rapid decline of population and welfare. The focus of the environmental debate thus became the apparent contradiction of having to meet the needs of humans both now living and of future generations, while taking into consideration the limits posed by the natural and social environment. As a conceptual tool in the process, the now widely spread term sustainable development emerged and was popularized through the WCED report *Our Common Future* (WCED, 1987) and the 1992 Earth Summit in Rio de Janeiro. The term focuses on intra-generational as well as inter-generational justice and the interdependence of the three dimensions of sustainability: the environment, the economy and the social sphere.

Fortunately the doomsday scenarios of *The limits to growth* have not materialised (so far). Part of the answer to why this has not happened can be found in the fact that the study underestimated the potential of technological development and the possibility of substitution. New clean technologies are normally brought forward as one of the key solutions to environmental problems. Not just because, by substituting older, dirtier technology they reduce environmental impact but also because they can induce economic growth. To be able to harness the benefits of new clean technologies the European Commission has launched the European Technology Action Plan (ETAP). The main objectives in the action plan are to *remove barriers for the development and diffusion of environmental technologies*, to *ensure that the EU will take a leading role in developing and applying such technologies*, and to *mobilize all stakeholders in support of these objectives* (EU, 2004). Thus ETAP fits well in the Lisbon strategy set by the Commission in 2000 with the commitment to bring about economic, social and environmental renewal in the EU and thus to render the EU the most dynamic and competitive economy in the world.

In accordance with these objectives of the EU Commission, the present study aims to identify *policy pathways* to the promotion of *clean technology development* (POPA-CTDA, the acronym of the project) in industry. In order to do so, the behavioural approach of Montalvo (2001) is used to determine the driving as well as inhibiting forces of the innovative behaviour of firms. In this specific case study, actors within the building sector are asked about their opinions concerning the production of energy efficient buildings. Various aspects of their attitude were addressed, such as economic and environmental risks perception, relevant pressures arising from the social environment, the market and the regulatory bodies and of their own technical and managerial capabilities. Eventually, the evaluation of the survey is used to identify some possible policy instruments that could be used to specifically support the development of more energy efficient buildings.

The structure of the report follows the methodological approach. After a more detailed description of the methodology in chapter 2, the following sections summarize the results of the survey with regard to the attitude of companies towards the expected outcomes of engaging in the production of energy efficient buildings (chapter 3), the perceived pressure from the social norm outside of the company (chapter 4) and the companies' own capacities and their perception of control over the innovation process (chapter 5). Chapter 6 combines these three strands by determining the specific contribution of each of them to the willingness of the companies to produce (or adopt) energy efficient buildings. This knowledge is used in chapter 7 to determine the changes in attitude and condition that are most likely to increase the companies' willingness to engage in energy efficient buildings and some hints on policy measures that can influence the attitude. In chapter 8 the results are put into the context of the overall work of the project.

## 2 Methodology

### 2.1 Selection of case study

Within the area of energy two case studies have been carried out to be able to cover both supply and demand. Renewable energy technology for production of electricity and energy efficiency in buildings were identified as key issues in the respective field. The selection of the building sector as one of the case studies can be motivated by its contribution to the overall energy demand. In the EU approximately 40% of the total energy demand stems from the building sector (EU, 2001) and, hence, the single largest user of energy. This demand has had an upward going trend and according to OECD this trend seems to be continuing (OECD, 2001). Focusing on residential buildings, most of this demand, more precisely 57%, is used for space heating. In the “Directive on energy performance of buildings” (EU, 2001) a saving potential of 22% compared to today’s consumption levels of energy used for heating, hot water, air-conditioning or lighting, is estimated and can be realised by 2010. Apart from its major contribution to the energy demand the building sector has also been chosen due to:

- energy efficiency potentials are significant in both the EU-15 countries and the accession countries, even though in varying magnitudes;
- the large amount and variety of actors such as contractors for installation of energy services, construction firms and real-estate owners;
- the longevity of buildings make decisions taken in the construction process of today crucial in shaping the future energy demand;
- the high discrepancy between owners and users has an impact on the incentives for investments in energy efficiency.

This case study differs slightly from the others in the project since we have not chosen to focus on one specific clean technology but instead the concept of a more energy efficient building. When faced with the task of reducing the energy required for heating buildings

there exists a range of technologies that can be utilized (low-e windows, heat-recovery ventilation, heat pumps, etc). Many of these are commercially available on the market today and the need for development is thus not the central issue. The implementation and integration of these technologies in the building process and the innovation of the building process are instead issues of much larger interest to the study.

## **2.2 The model used in the case study**

As the title ‘Policy pathways to the development and adoption of clean technologies’ suggests, it is the aim of this project to identify those policy measures that could provide positive, and reduce negative, incentives for managers and entrepreneurs to develop or adopt new, cleaner technologies – in this case energy efficient buildings. A major first step to the achievement of this goal consists of the empirical analysis of the incentive structure guiding the strategic behaviour of the decision makers in relevant companies. The empirical approach used to carry out this analysis has been developed by Montalvo (see Montalvo, 2001 & 2002) and is based on a behavioural model designed to understand and, to some extent, predict human social behaviour on the basis of the underlying intentions, attitudes, subjective norms and behavioural control (Ajzen, 1988 & 1991). Accordingly, behaviour, at the most basic explanatory level, is considered as a function of salient beliefs which are formed by associating positive or negative connotative meaning to the most relevant aspects of behaviour such as people, objects, activities and their attributes. With regard to the study of innovative behaviour, the model suggests that the innovative activities executed by a company are reflected in its relevant decision makers’ willingness to innovate, which in turn is determined by their (1) attitude toward innovation, (2) their perceived social pressures to innovate and (3) their perceived control over the innovation process.

The attitude toward innovation is an indicator of the degree to which relevant decision-makers like or dislike (i.e. form positive or negative connotation with) the expected direct outcomes of their engagement in innovative activities. Typically these outcomes refer to economic activities representing the core business of the innovative entrepreneur and, in

the case of an intentional engagement in clean technology, possibly also the positive effect of the latter on the environment. We therefore distinguish perceived economic risk (and to a lesser extent potential), *ER*, and the perceived environmental risk, *EV*, as the main determinants of the entrepreneurs' perceived attitude, *A*, toward an engagement in clean technology innovation.

In contrast to attitude, perceived social pressure (*P*) refers to the positive or negative normative connotations associated with those aspects of an engagement in cleaner technologies that are connected with the innovation process not directly but via the feedback on it of different parts of the social environment. In particular, we distinguish (1) the regulatory pressure, *RP*, which refers to the perceived stringency of environmental regulations and standards and the degree of their enforcement, (2) the market pressure, *MP*, that may arise from the perceived attitude of consumers and competitors concerning the cleaner technology and (3) the perceived pressure from stakeholder groups in the community forming the social environment of the innovating firm (*CP*).

The third category of determinants refers to the entrepreneurial decision-maker's perceived control of the innovation process, *C*. This part of the belief system essentially comprises (1) the technical capabilities (*TC*) of the company, including the technological opportunities offered by the market, and the company's capability to (2) react on such opportunities and to engage in organisational learning (*L*), (3) to form strategic alliances (*AL*) with customers or suppliers and (4) to use collaboration networks (*NK*) with research institutions in order to outsource the acquisition of knowledge needed for the innovation process.

After all, the contribution of the above-mentioned aspects of the decision-makers' belief system to his willingness to innovate (*W*) and the relation between this willingness and his actual innovative success (*I*) can be concluded in the following hypotheses.

H<sub>1</sub>: The engagement of firms in the development or adoption of a new (cleaner) technology (*I*) can be explained by their leaders' willingness (*W*) to do so which is

itself determined by their perceived attitude towards innovation (*A*), their (perceived) social pressure to innovate (*P*) and their (perceived) control over the innovation process (*C*):

$$I \sim W = W(A, P, C) \quad (1)$$

H<sub>2</sub>: Perceived environmental risk (*EV*), economic risk (*ER*), community pressure (*CP*), market pressure (*MP*), regulatory pressure (*RP*), technological capability (*TC*), organisational learning (*OL*), strategic alliance formation (*AL*) and networks of collaboration (*NW*) consistently contribute to attitude, social pressure and control and, eventually the firm leader's willingness to engage in the development or adoption of the new, cleaner technology, yielding the following extension of equation (1):

$$I \sim W = W(EV, ER, CP, MP, RP, TC, L, AL, NK) \quad (2)$$

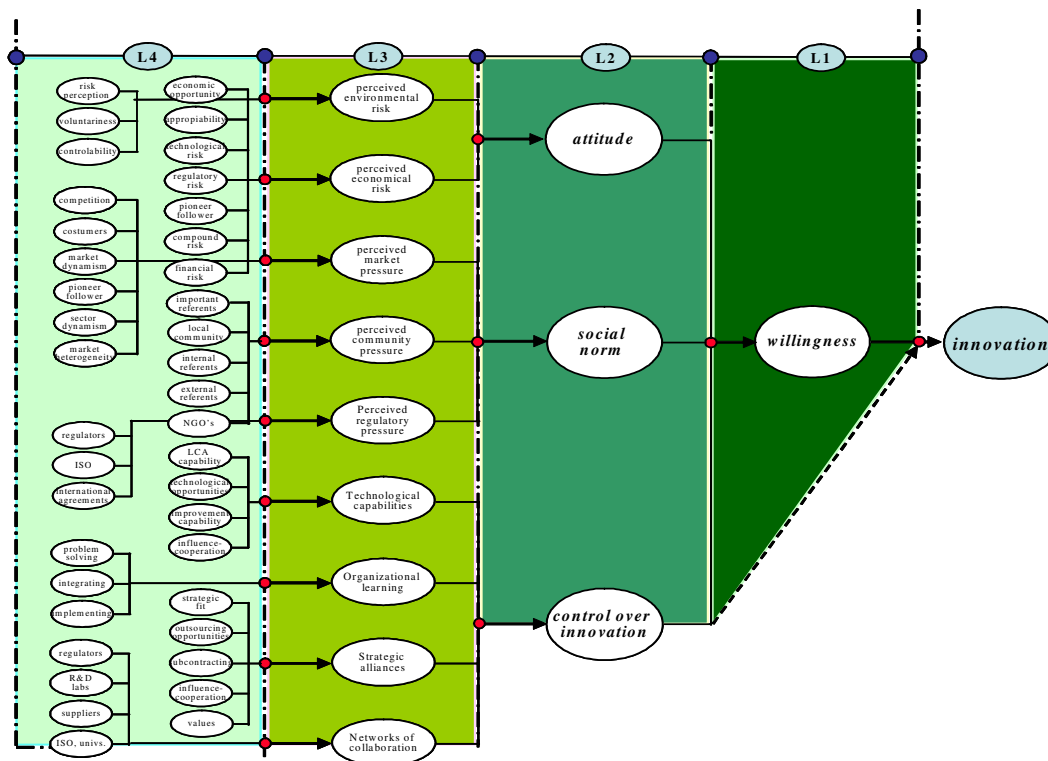
H<sub>2a</sub>: Proportionality exists between the scores on each domain scale (e.g. *ev<sub>i</sub>*, *er<sub>i</sub>*, etc.) and its respective domain index (*EV*, *ER*, etc). This implies that the willingness to engage in the development or adoption of the new, cleaner technology can alternatively be explained by the accumulated connotative load of the domain scales. The relationship can be explained by altering equation (2) into:

$$I \sim W = W(\sum ev, \sum er, \sum cp, \sum mp, \sum rp, \sum tc, \sum l, \sum al, \sum nk) \quad (3)$$

While hypothesis H<sub>1</sub> refers to the link between actual behaviour, *I*, and the willingness to execute this behaviour, *W*, as expressed by its components *A*, *P* and *C*, hypothesis H<sub>2</sub> refers to the consistency between the willingness and its constituting determinants *EV*, *ER*, *CP*, *MP*, *RP*, *TC*, *OL*, *AL* and *NW* and hypothesis H<sub>2a</sub> is only an alternate way of expressing this relation. The latter aspect will also concern the third level of determinants that will be constituted implicitly by the matrix of definition and the questions derived from it (see below).

### 2.3 Development of the questionnaire

The central, empirical part of the analysis undertaken in the POPA study is a survey involving a questionnaire based on, and exploiting, the behavioural model and the assumptions described in section 2.2. The development of the questionnaire consists of five steps. The first step entails the conduction of a series of interviews to reveal the relevant information determining the decision of entrepreneurs to develop or adopt cleaner technologies. The structure of the interviews closely follows the behavioural model developed in section 2.2 and includes the first three levels shown in the structural scheme in Figure 1.



**Figure 1** Schematic illustration of the levels of explanation of the firm's innovative behaviour

The second step comprises the identification of barriers and drivers to the development and diffusion of stationary fuel cell technology from the interview responses and the alignment of the results with those of the literature screening undertaken in view of the case study selection described in section 2.1 (i.e. WP1 of the project). As the questionnaire addresses (potential) innovating entrepreneurs, barriers and drivers to other

stakeholders are only accounted for at this stage, if they are also relevant for the entrepreneur. Outcome of this step is a list of factors that, according to the interviewees, positively or negatively affect the innovation process for cleaner technologies.

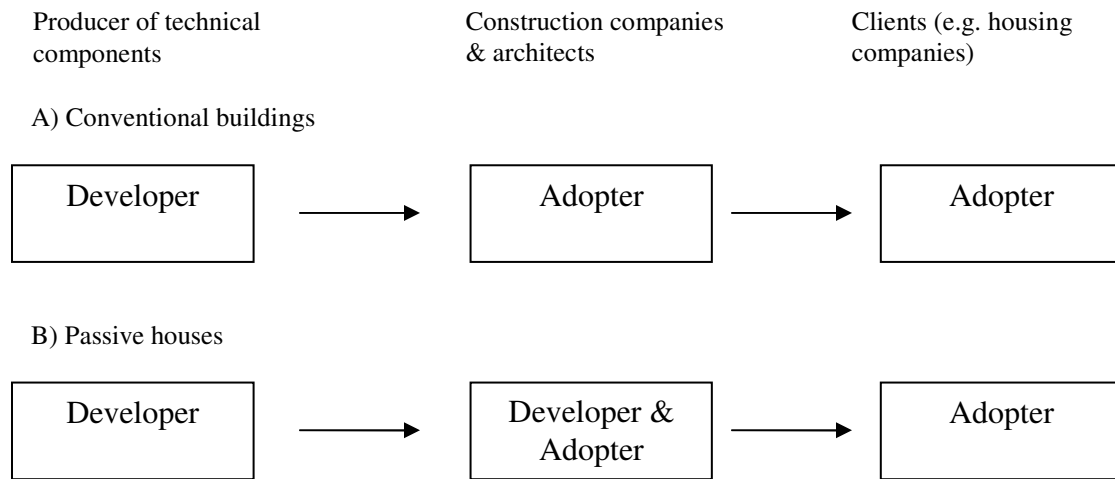
The third step consists of creating a system of hypotheses linking barriers and drivers to the actual development or adoption of the cleaner technology. In order to do this in the most systematic manner and thus avoid multiple assessment of some factors while others may not be accounted at all, each of the factors identified in step 2 is given a definition and assigned to one of the concepts on level 3 via a hypothetical function which also determines the expected kind of correlation between the appearance of the factor and eventually the willingness to innovate.

In the fourth step, questions to be included in the questionnaire are formulated in close accordance to the hypothetical construct and in a way that allows for easy answering and evaluation of the answers by means of multiple-choice answers on the basis of a well-defined 7-point scale ranging from one extreme of an attribute (e.g. 'very unlikely') to the other ('very likely'). Thereby it was tried (but not always succeeded) to orient the scale in such a way that the change of the attributes from the far left (equivalent to 1 point) to the far right (equivalent to 7 points) at the same time represented an increase in the likelihood that the respondent will indeed engage in the new technology.

In the last step, the questionnaire is tested with respondents that are willing not only to complete the questionnaire but also to give comments on its contents.

## **2.4 Selection of questionnaire addressees**

Since the subject of our case study is not one clean technology, but instead a more complex process of building an energy efficient building the distinction between adopters and developers becomes slightly different from the other case studies. Two different cases have been identified.



**Figure 2** Scheme over the distinction between developer and adopter for the actors of the buildings sector used addressed in the questionnaire

As Figure 2 illustrated producers of technical components such as low-e windows or heat pumps can be seen as the true developers in the building sector. These components are then adopted by construction companies and included in the building. The finished building is then “adopted” by various housing companies. This reasoning can be applied to the construction process of conventional buildings, but if one wants to radically reduce the energy requirements for heating the view of the chain has to be slightly altered. For example in the so called passive houses (according to CEPHEUS these are houses with space heat requirement of 15 kWh/m<sup>2</sup>) the whole building can be interpreted as a new concept. In this case the architect and the construction company still adopt specific technical components but can also be seen as the developer of the “new type of building”.

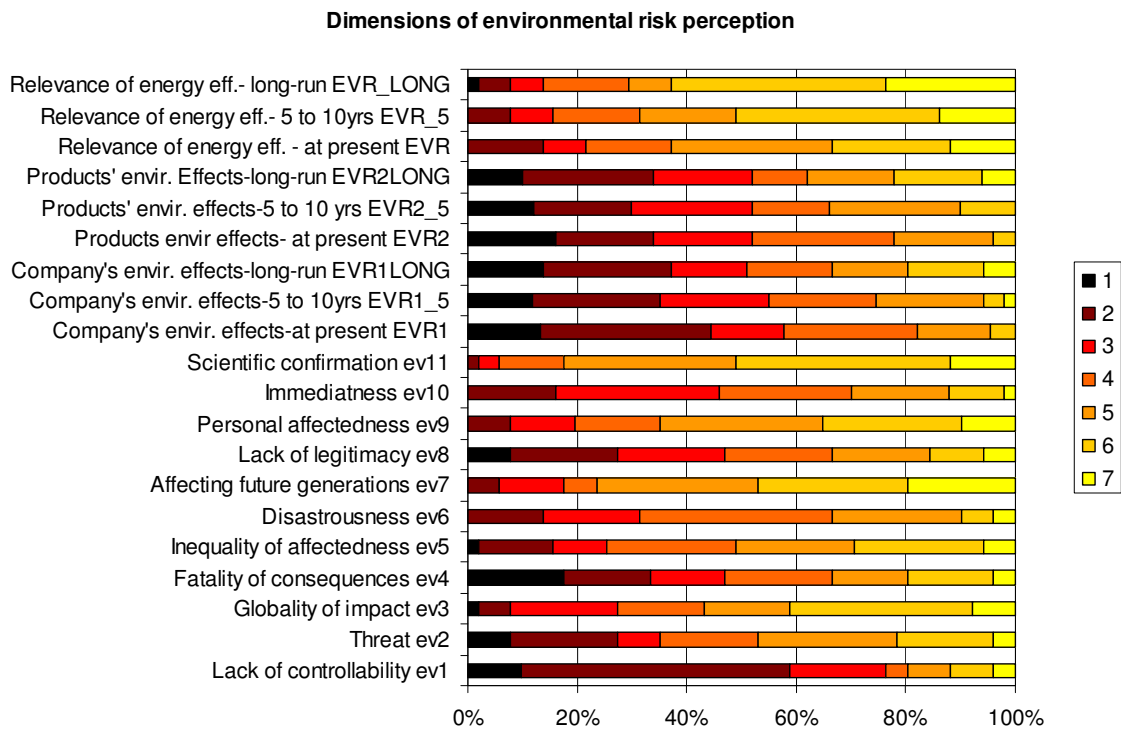
The questionnaire was sent out to 150 actors within the Swedish building sector: 40 architects, 30 building companies, 25 technical companies, 55 housing companies out of which 10 coops, 10 privately owned and 35 public. These were identified through a database of Swedish companies (PAR-guide). The selection of actors was made through the number of employees: for the architects the lower limit was 10 employees, for construction companies 100, for the technical companies 50, for housing companies 50.

We received 4 respondents that did not want to reply and 51 replies, giving us a response frequency of 37%. The responses are divided among the actors in the following way: 6 architects (15% response rate), 12 building companies (40% response rate), 9 technical consultants (36% response rate), 24 housing companies (44% response rate) : 4 coops, 3 private and 17 public.

### 3 Attitudes and expectations concerning the engagement in energy efficient buildings

#### 3.1 Environmental risk perception

The respondents were asked to answer question of how they perceived the environmental effects generated by the usage of energy in conventional buildings. The results are summarised in Figure 3.



**Figure 3:** Frequency of response to the questions concerning environmental risk perception. Scores range from 1 (very weak perception) to 7 (very strong perception).

The average score of the responses to the questions concerning environmental risk perception (*ev1* to *ev11*) is 4.2. With average scores above 5 we found that a large majority of the respondents believe that the environmental effects are scientifically confirmed (*ev11*, average: 5.4) and that they affect future generations (*ev7*, average: 5.2).

A large group of respondents also believe that the effects will affect them personally (*ev9*, average: 4.8) while at the same time having a global impact (*ev3*, average: 4.7) and affecting people unequally (*ev5*, average: 4.4). Slightly lower averages, but still in the upper half, are found in the responses that describe the effects as: threatening (*ev2*, average: 4.0), catastrophic (*ev6*, average: 4.0), arising immediately (*ev10*, average: 3.8), not legitimate (*ev8*, average: 3.7) and with fatal consequences (*ev4*, average: 3.6). The lowest score (average: 2.9) is the perception that the effects are uncontrollable (*ev1*).

The correlation between the average answers to the questions *ev1* to *ev11* and the general (momentary) affects of the operation of the firm of the respondent (EVR1) is low with an  $R^2$  value of 2.2. The  $R^2$  increases slightly for the effect in the future being 2.85 for the medium range effects (next 5 to 10 years) and 3.3 in the long run. The low correlation could be explained by the fact that when the respondents rank the effects of the daily operations of the company between negligible and very dramatic the average is 3.1, increasing slightly in the perception of the future (3.3 and 3.5), while the average of the general questions (*ev1* to *ev11*) is relatively higher. This could be explained by the fact that the first questions were concerning the general effects of the usage of energy in conventional buildings, while EVR1 concerns the daily operations of the company, which might be e.g. drawing buildings for architects. The connection between the two is not always obvious.

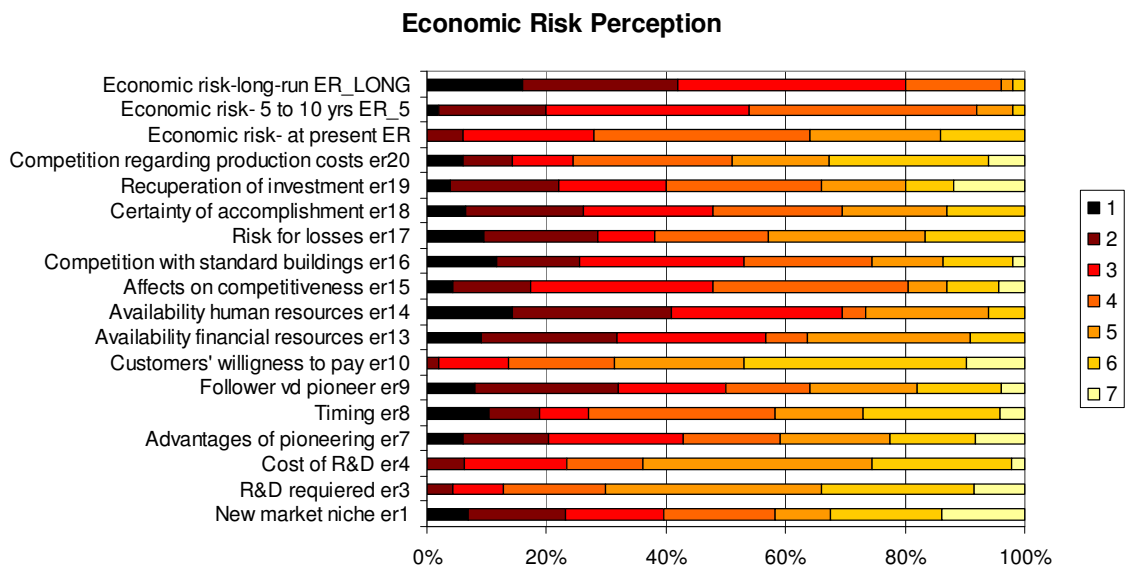
EVR2 instead asks about the environmental effects generated by the usage and disposal of the products and should thus show a better correlation. This is the case but only slightly for the new  $R^2$  value is 2.9 and the average is 3.2. The low levels of this case could be explained by the fact that new buildings are perceived as being more energy efficient than old ones and thus with lower environmental impact. The correlation increases slightly in the medium range (5 to 10 years, average: 3.5,  $R^2$ : 0.3) but, even if the average increases in the long run the correlation decreases slightly (average: 3.7,  $R^2$ : 0.27). To the question of how relevant it was for the firm to improve energy efficiency in buildings, taking into consideration the environmental effects the average score is 4.7 at present, 5.1 in the next 5 to 10 years and 5.3 in the longer run.

An environmental risk composite index was also computed from the answers to EVR1 and EVR2. The correlation of this index with questions assessing environmental risk perception is given by  $R^2$  values of 0.25 at the present, 0.29 in the next 5 to 10 years from now, and 0.32 in the longer run.

A more detailed regression model was made to try to identify which factors were most representative for the environmental risk index. For “...at the present” the best representation is found in the responses to questions of the fatality of the consequences (*ev4*), the personal affectedness (*ev9*), the threat (*ev2*), and the disastrousness (*ev6*). The  $R^2$  value for this regression is 0.27. For “...in the next 5 to 10 years” the best fit is achieved by using the fatality of consequences (*ev4*), the disastrousness (*ev6*), and the affect on future generations (*ev7*). The  $R^2$  value in this case is 0.37.

### 3.2 Perceived economic risk

Another dimension of the general attitude to energy efficient buildings is the perceived economic risk, thus the respondents were asked about their opinion on the benefits and the risks of producing more energy efficient buildings for their company. The results are shown in Figure 4.



**Figure 4** Frequency of responses to the questions concerning the perception of economic risk. Scores range from 1 (low risk) to 7 (high risk).

The average of the scores for the questions on economic risk (*er1* to *er20*) is 4.0, showing that the companies perceive a certain risk even if this is not extremely high. The highest risk is perceived in the customers' lack of willingness to pay for more expensive but more energy efficient buildings (*er10*, average: 5.1). The R&D required to produce buildings with higher energy efficiency is also seen as large (*er3*, average: 5.0), while to the question if the costs of this R&D (*er4*) are minimal (1) or great (7), the average response score is 4.6. Connected with the costs is also the question if low energy buildings can compete with standard buildings in terms of production costs (*er20*), the average response score is 4.4 (1: very competitive, 7: very uncompetitive), the question if the extra investments will be recuperated from the customers (*er19*) with an average response of 4.0 (1: very likely, 7: very unlikely), and what likelihood that the production of energy efficient building will lead to substantial losses (*er17*) with an average of 3.8 (1: very unlikely, 7: very likely). Average scores around 4 are received for the questions if energy saving technologies have created a new market niche for the firm (*er1*, average: 4.2), if the venture of low energy buildings is "ahead of its time" (*er8*, average: 4.2) and the how large the advantages of pioneering will be (*er7*, average: 4.0; 1: great, 7: minimal). The related question if the company prefers to be a follower rather than a pioneer (*er9*) the average is 3.7. For the availability of resources, financial resources (*er13*, average: 3.5) seem to be more scarce than human resources (*er14*, average: 3.1). The production of energy efficient buildings does not seem to have much of an affect on the competitiveness of the firm (*er15*), neither in the positive nor the negative direction (average: 3.7). The same could be said about how well low energy buildings compete to standard buildings in terms of comfort (*er16*, average: 3.5). The certainty of accomplishment of a venture of producing low energy buildings (*er18*) also receives a mediocre average score (3.6).

The economic risk perception seems to diminish with time, averages scores go from 4.2 for "...at the moment", to 3.3 for "...in the next 5 to 10 years" and 2.7 in "...in the longer run". It should be noted that to keep the range the same between the questions *er1* to *er20* and the general questions, the late ones were inverted compared to the questionnaire

found in the appendix. The general question on economic risks reflects quite badly the dimensions brought up in the questions *er1* to *er20* since the  $R^2$  values are 0.1, 0.17 and 0.09 from the various time periods. A much better fit is achieved by just using a few of the questions as predictors ( $R^2$  value of 0.49). The key components in this case are: the R&D required (*er3*) and the costs associated with the R&D (*er4*), the customers' willingness to pay for more energy efficient buildings (*er10*), the willingness to be a pioneer or follower (*er9*), the creation of a market niche (*er1*), the affects on competitiveness (*er15*), the risk for losses (*er17*), the competitiveness of low energy buildings with standard buildings (*er16*), and the possibility to recuperate the extra investment needed from the customers (*er19*).

### 3.3 Attitude as a whole

At the end of the questionnaire a general attitude question was posed (A2). We will now see how well the responses to these questions represent the environmental index used in section 3.1 and the general question on risk perception (ER).

**Table 1** Regression of the attitude towards the production of energy efficient buildings on combined environmental and economic risk perception (unstandardised coefficients).

Variables	Attitude (A2)		
	At present	5 to 10 years	In the long run
Mean of EVindex, ER <sup>1</sup>	0.75***	0.48***	0.28**
Constant	2.5	3.5	4.5
R <sup>2</sup>	0.42	0.29	0.13

\*\*p<0.01;\*\*\*p<0.001

The best correspondence is with the momentary value, with quite a good  $R^2$  value and a coefficient close to 1. As the time perspective increases one can observe that the overall

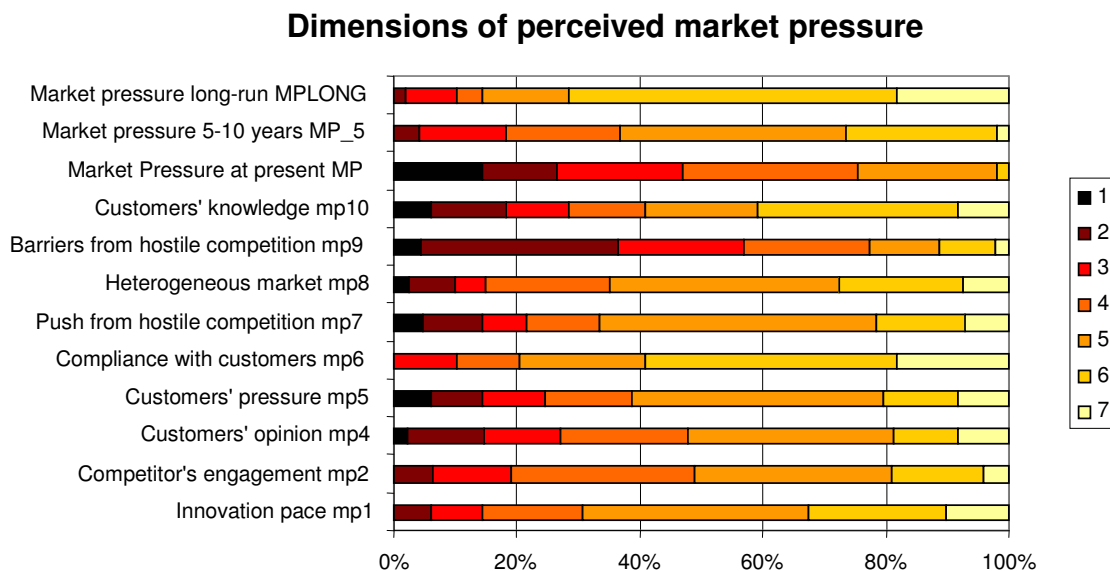
<sup>1</sup> Each independent variable for the respective time horizon of the dependent variable.

attitude becomes more positive than the combined risk perspective (the intercept increases).

## 4 Willingness to comply with social norms

### 4.1 Perceived market pressure

The third section of the questionnaire assesses the perception of signals from the market. The summarized results can be seen in Figure 5.



**Figure 5:** Frequency of response to the questions concerning market pressure. Scores range from 1 (very unlikely/low pressure) to 7 (very likely/strong pressure).

The average score is 4.55 (*mp1* to *mp10*) and the range is from 3.4 (*mp9*) to 5.5 (*mp6*). The highest score show that the respondents generally do what the customers think that they should do about the environmental issues (*mp6*). While for the question if the customers will push them to produce building with higher energy efficiency the average is slightly lower (*mp5*, average: 4.45), which is more or less the same average as the replies to the question if the customers think that the company should produce buildings with higher energy efficiency (*mp4*, average: 4.35). The reply to the question if customers

lack enough knowledge about energy efficiency to be able to create a demand (*mp10*) the average is 4.6. These results may show that the companies are sensitive to the opinions and demands from the customers, but that these do not always have enough knowledge to push towards energy efficient buildings.

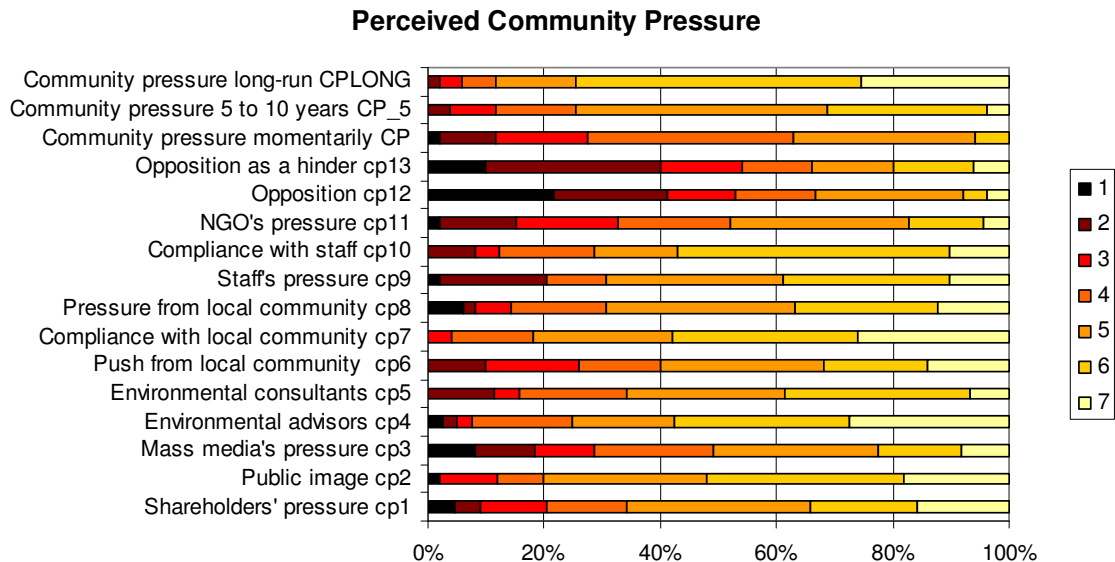
Regarding the competition in the industry, the pace of technological innovation is seen to be relatively high (*mp1*) as an average of 4.9 illustrates. The score from the question concerning the heterogeneity of the market and its power to push the company to produce energy efficient buildings (*mp7*) is also in the higher range with an average of 4.7. Slightly lower but still with an average above 4 are the answers to the questions about hostility of the competition and its affect on the production of energy efficient buildings (*mp6*, average: 4.5) and if the competitors will be producing energy efficient buildings. The lowest average is for the question concerning the hostile competition being a barrier to the production of energy efficient building (*mp9*, average: 3.4). Summarizing one could say that there is a pressure from competitors and that this has a positive effect on the production of energy efficient buildings.

The general question on market pressure at the moment (MP) is much lower than the average of the questions *mp1* to *mp10*, i.e. 3.4 also yielding a low correlation of the two with an  $R^2$  value of 0.21. If in stead the market pressure in the future is considered the averages increase to 4.7 and 5.6 for the 5 to 10 year and the long-run respectively. But no improvement is made on the  $R^2$  values (0.21 for the 5 to 10 year and 0.085 for the long run).

In attempt to make a better model a stepwise regression was made on the various answers to try to identify the important questions. The best model was achieved by only using *mp4*, *mp5*, *mp7* ( $R^2$  value of 0.6), meaning that the most important pressure is from the competition on the market and the pressure from customers.

## 4.2 Perceived community pressure

The aim of this section of the questionnaire was to assess other forms of pressure from the socio-cultural environment. The frequencies of the answers can be found in Figure 6.



**Figure 6** Frequency of responses to the questions concerning the perceived pressure from the community. Scores range from 1 (very weak) to 7 (very strong)

The average of all the responses of questions *cp1* to *cp13* is 4.7 and average scores for each question range from 3.3 (*cp12*) to 5.6 (*cp7*). It is to be noted that the question with the lowest average *cp12* is the perception of the existence of groups opposing energy efficiency in buildings. The average of the question if this opposition constitutes a barrier to energy efficiency in buildings (*cp13*) is slightly higher, i.e. 3.6. The strongest pressure is perceived as coming from the environmental advisor (*cp4*, average: 5.5), the local community (*cp8*, average: 4.9), the shareholders (*cp1*, average: 4.8) and the staff (*cp9*, average: 4.8). Slightly lower averages are found for the pressure from the mass media (*cp3*, average: 4.3) and the NGOs (*cp11*, average: 4.2).

Generally the respondents seem to believe that the company does what the various actors think that they should do. The strongest pressure seemed to come from environmental advisors and the average response to the question whether the company does what the

environmental consultant thinks that they should do regarding the production of energy efficient buildings (*cp5*) is also quite high, i.e. 4.8. Concerning the local community two questions were posed slightly differently: the first asking if the local community will be pushing the company to produce energy efficient buildings (*cp6*) and the second was if the company does what the local community thinks that it should do regarding environmental issues (*cp7*). The second question received a higher average, 5.6, probably because environmental issues are much wider than just the production of energy efficient buildings and that the pressure from the local community might have been focused on local environmental problems for a longer time. The first receives an average of 4.7, still a quite high average, showing that their role is not unimportant. For the general question if the company does what the staff thinks it should, the average is quite high: 5.2 (*cp10*). This result could mean that if the staff would start to push strongly for the production of energy efficient buildings this might have an effect on the company. In the end the importance of energy efficient buildings for the public image the average (*cp2*) is 5.3.

The aggregate question concerning the present community pressure had a lower average score of 4.0. The regression of these answers to the average of *cp1* to *cp13* showed very low correlation, with an  $R^2$  value of 0.095.

The pressure is presumed to increase in the future since the average of the questions concerning the pressure 5 to 10 years from now and in the long run are higher (4.9 and 5.9 respectively). The correlation with the questions increases also but is still low ( $R^2$  value 0.17 in both cases).

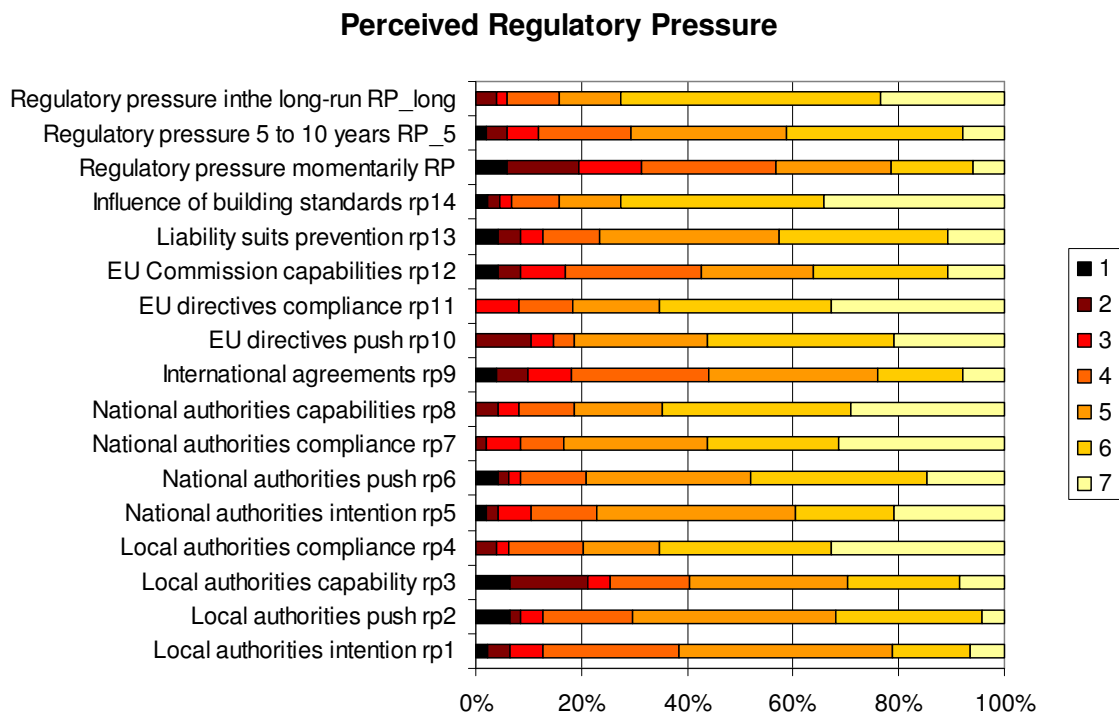
A better model was attempted by making a regression to the individual responses. Through stepwise regression the most important factor is identified as being question *cp6* concerning the local communities ability to push the company.

The best result is achieved by using the responses to questions *cp6*, *cp8*, *cp13*, *cp11* and *cp12*, with an adjusted  $R^2$  of 0.39, showing that the relevant questions are about the local community (*cp6* and *cp8*), the NGOs (*cp11*) and the opposition to energy efficient buildings (*cp12* and *cp13*). The significance of the last three questions (*cp11*, *cp12*, *cp13*) may seem a peculiar result since individually the pressure from these groups is perceived

as lower. An interpretation may be that they are the reason why the general pressure is not seen as being larger.

### 4.3 Perceived regulatory pressure

Section V in the questionnaire assessed the influence that regulatory institutions have on the decision of companies to build energy efficient houses. As in the previous section the frequencies are presented below (Figure 7).



**Figure 7** Frequency of responses to the questions concerning regulatory pressure. Scores range from 1 (very low pressure) to 7 (very strong pressure)

High scores are quite dominant yielding an average score of 5.2 for the questions *rp1* to *rp14*. The influence of building standards (*rp14*) and the compliance with EU directives (*rp11*) receive the highest scores, 5.8 and 5.7 respectively. The influence of the building standards was also emphasized in the interviews, were all respondents pointed out that the building standards were both the minimum and the maximum level of investment for energy efficiency. In Sweden there has lately been a lot of discussion around the EU

Directive on Energy Performance of Buildings. The results of the questionnaire show that this will probably have an important influence in the Swedish building sector. The average score on the question if the EU Directives such as the Directive on Energy Performance of Buildings will push the company to produce energy efficient buildings (*rp10*) is lower 4.7. The more general question if the EU Commission can force the company to produce more energy efficient buildings (*rp11*) has a slightly higher score, i.e. an average of 5.3. These results illustrate that the pressure from the EU may be important.

A group of questions on the pressure from the local public authorities were posed, all receiving similar averages above 4.5 (*rp1*, average: 4.7; *rp2*, average 4.8; *rp3*, average: 4.5) except the question concerning how well the company complies with the will of the local authorities on environmental issues (*rp4*) which received a higher average response score of 5.7. The first question was if local public authorities think that the company should produce buildings with higher energy efficiency (*rp1*); the second question was concerned with the push from the local authorities (*rp2*); and the third one asked if the local authorities have the capacity to force the company to produce buildings with higher energy efficiency (*rp3*).

Similar questions were posed about the intentions (*rp5*), the pressure (*rp6*), the capabilities (*rp7*) and the compliance (*rp8*) with the national authorities. The scores in this case were higher with all averages above 5. The question concerning the capabilities and compliance are the once that receive the highest scores, both with an average of 5.6; while the intention and the pressure both have an average of 5.2.

The influence of international agreements such as Kyoto (*rp9*) received a slightly lower average of 4.6 and pre-empting the risk of future liabilities (*rp13*) receives an average of 5.0.

The response to the more general question on the momentary regulatory pressure received, just as the other general questions, a lower average than the average of the

specific questions. The average score is 4.1. The averages increase slightly for the midterm perspective, 5.0 and even more for the long run 5.7.

The correlation between the average of all the questions and the general question was low with an  $R^2$  value of 0.14, slightly higher for the midterm and long-term perspective, in both cases the  $R^2$  value is 0.23.

The best model for the momentary regulatory pressure is one including the responses to *rp2*, *rp3*, *rp4*, *rp7*, and *rp9* with an  $R^2$  value rising to 0.23. Three of the questions are concerning the local authorities, one about the national authorities and one about international agreements. But these questions do not always correspond to the highest perceived pressure based on the responses to the specific questions. A better fit is found when the dependent variable is the midterm regulatory pressure. In this case the questions that give the best model are *rp1*, *rp2*, *rp4*, *rp9*, *rp10* with an  $R^2$  value of 0.53. The results are similar to the momentary pressure with the difference that the national authorities are not included; pressure from EU Directives is instead.

#### **4.4 Social pressure in general**

We will now try to see how well the combination of the assessed market pressure (MP), community pressure (CP) and regulatory pressure (RP) can express the comprehensive category of social pressure in general. In the questionnaire two general questions were posed: one concerning social pressure in general and the second one concerning pressure from stakeholders. Through two regressions we assess how well these questions capture the three dimensions of social pressure, using the respective general question as a dependent variable. In both cases the corresponding average score of MP, CP and RP are used as independent variables (see Table 2).

**Table 2** Regression of the impact (on the production of energy efficient buildings) of the social environment in general on the combined effect of perceived market, community and regulatory pressure (unstandardized coefficients).

Variables	Social pressure in general			Pressure from stakeholders		
	At present	5 to 10 years	In the long run	At present	5 to 10 years	In the long run
Mean of MP, CP, RP <sup>2</sup>	0.96***	1.07***	1.02***	1.03***	0.96***	1.00***
Constant	0.11	- 0.47	-0.18	0.08	0.14	-0.11
R <sup>2</sup>	0.53	0.66	0.7	0.55	0.58	0.60

\*\*\*p<0.001

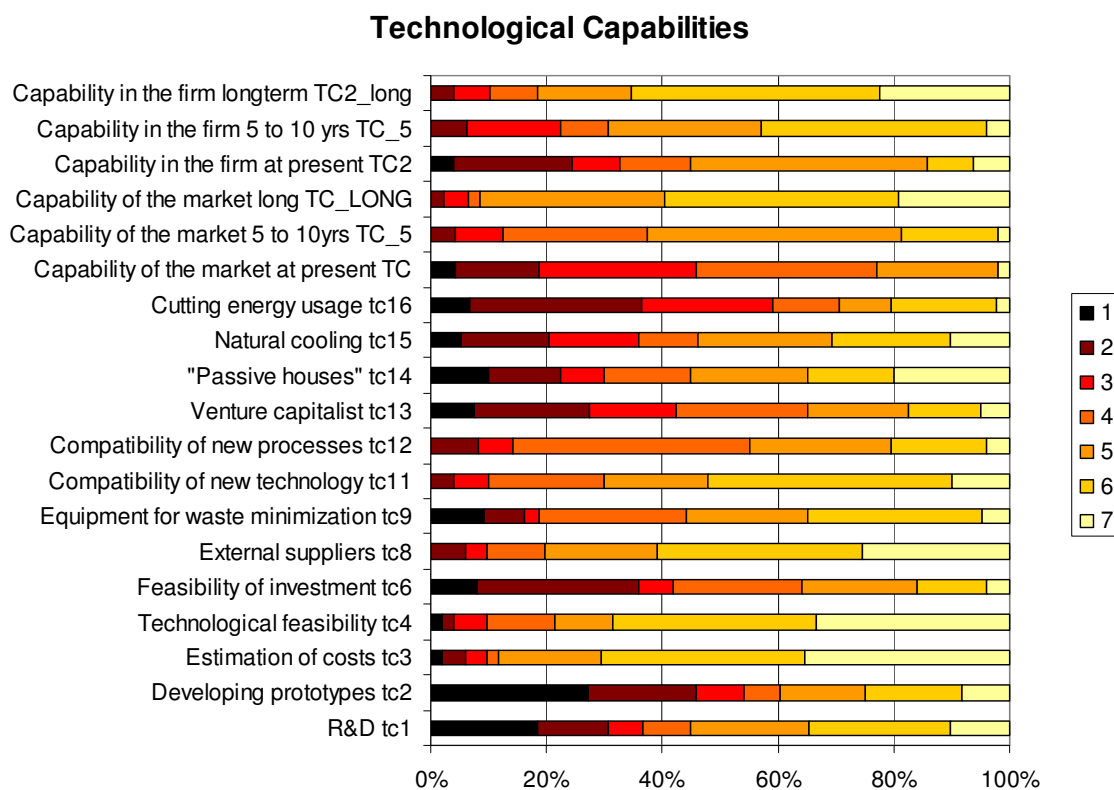
For all regressions the R<sup>2</sup> values are high (above 0.5) and all coefficients are significant and around 1. Thus the summarizing questions represent well the corresponding specific pressures.

<sup>2</sup> Each independent variable for the respective time horizon of the dependent variable

## 5 Control over the innovation process

### 5.1 Technological capability

In section VI of the questionnaire the respondents were asked about the technical and organizational capabilities that are needed to produce energy efficient buildings. The distribution of the scores assigned to the questions is shown in Figure 8.



**Figure 8** Frequency of responses to the questions concerning technical and organizational capabilities. Scores range from 1 (very low capabilities) to 7 (very high capabilities).

The overall average of the responses to questions *tc1* to *tc16* is 4.5, showing that the companies in general believe that they have moderately high technological capabilities to produce buildings with higher energy efficiency. The highest score and thus the highest estimated capabilities are found in the ability to estimate the costs of improving energy efficiency (*tc3*, average: 5.8), to assess the technological feasibility for improving energy

efficiency (*tc4*, average: 5.7) and to identify suppliers and procurement chains needed to improve energy efficiency in buildings (*tc8*, average: 5.5).

New energy saving technologies are seen to be quite compatible with the standard materials and inputs of the construction process (*tc11*, average: 5.2) while the response to the question of how compatible the new processes inherent in saving energy are to the conventional building process (*tc12*) have a lower average score of 4.5. The same average is also observed for the question on the procurement of equipment and machinery that can ensure waste minimization (*tc9*).

Lower scores are found for the R&D capabilities of the companies (*tc1*, average 4.1). Here it should be remembered that the questionnaire was distributed to many smaller actors, and actors such as housing companies that naturally do not have R&D departments. The mixture of actors may also explain the low score on the question of the capabilities to build and test experimental prototypes (*tc2*, average: 3.5).

The two question concerned with financial capabilities have lower averages. The ability to find venture capitalist (*tc13*) received an average of 3.8 and the average response score to the availability of slack resources for investment in innovative activities (*tc6*) was 3.7.

The last three questions were of a more specific nature. The first question assesses the company's capability to produce "passive houses", i.e. houses that do not need a conventional heating system. The average score was 4.5. 20 percent of the respondents replied "very likely" and 55% of them replied with one of the top three scores. A conclusion that could be drawn is that the low production of "passive houses" in Sweden is not due to a lack of capabilities. The capability of producing houses with natural cooling systems, i.e. cooling without mechanical air conditioning, got a slightly lower score of 4.3. Even in this case over 50% (53%) of the respondents answered with the highest scores.

The last question tried to assess the companies' ability to cut energy usage in existing buildings. The alternatives ranged from less than 10% to more than 70%. Only 2.3%

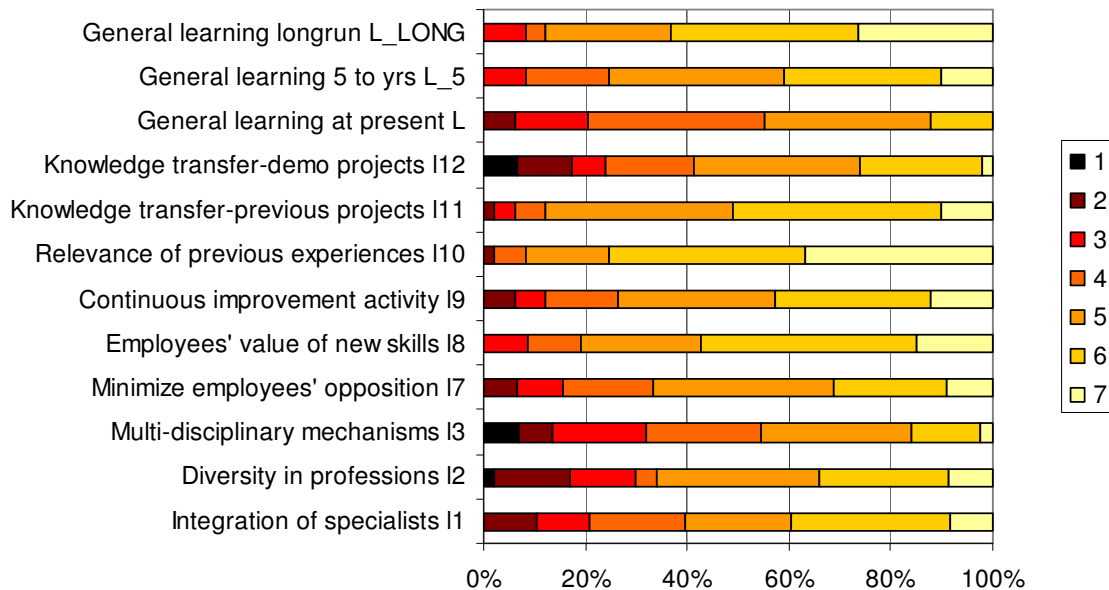
believed that they could cut with more than 70% while around 30% believed that they could cut the use with around 20%. The average of 3.5 could be interpreted as if the average energy usage cut could be of 35%.

The average response score to the general question about the level of knowledge in the marketplace is lower than the average of the responses to the questions *tc1* to *tc16*, i.e. 3.6. The average increases as the time horizon increase, for 5 to 10 years from now the average score is 4.7 and for the long term the score is 5.6. The best correlation between the general question and the average of the questions *tc1* to *tc16* is found with the midterm perspective, with the  $R^2$  value of 0.13, but even this one is very low. The general question about the technological capabilities in the firm received an average response score of 4.1 at the present, 4.9 in the next 5 to 10 years and 5.6 in the long run. These responses correlate much better with the average of the questions *tc1* to *tc16* with an  $R^2$  value of 0.35 for the capability at the present. The correlation is even better for the midterm perspective,  $R^2$  value of 0.41, but decreases for the long-run,  $R^2$  value of 0.30. It is not surprising that the general question about the capability in the firm has a better correlation with the *tc* questions since these were all more or less about capacity within the firm. When a regression was made to each question the best fit was achieved using the following questions as predictors: *tc4*, *tc14*, *tc6*, *tc13*, *tc16*, *tc12*, *tc15*, *tc3*.

## 5.2 Organisational learning

In section VII the internal capability to integrate and generate new knowledge concerning energy efficiency was assessed. Learning processes and knowledge issues were pointed out in the interviews as key issues. The frequencies of the answers to the questions are represented in Figure 9.

### Learning Capabilities



**Figure 9** Frequency of responses to the questions concerning organizational learning. Scores range from 1 (very low) to 7 (very high).

The average score of questions *I1* to *I12* is 5.0. The highest score is received for the question about the relevance of previous building projects (*I10*) with an average of 6.0. The related question if knowledge is systematically transferred from previous projects to new projects (*I11*) receives an average of 5.5 and from demonstration projects to new projects (*I12*) an average of 4.4. The high results of these questions are surprising if compared to the interview results where one of the major barriers identified where poor transfer of knowledge and the lack of learning processes in the building sector.

To the question how the company's employees value the experience of acquiring new skills and abilities (*I8*) the average response rate is 5.5 and the company's ability to minimize their opposition to learn new techniques and work practices (*I7*) is slightly lower, i.e. 4.8. An average score above 5 (more exactly 5.1) is found in the response to the question if the company can promote organization-wide continuous improvement activities aimed at producing energy efficient building (*I9*).

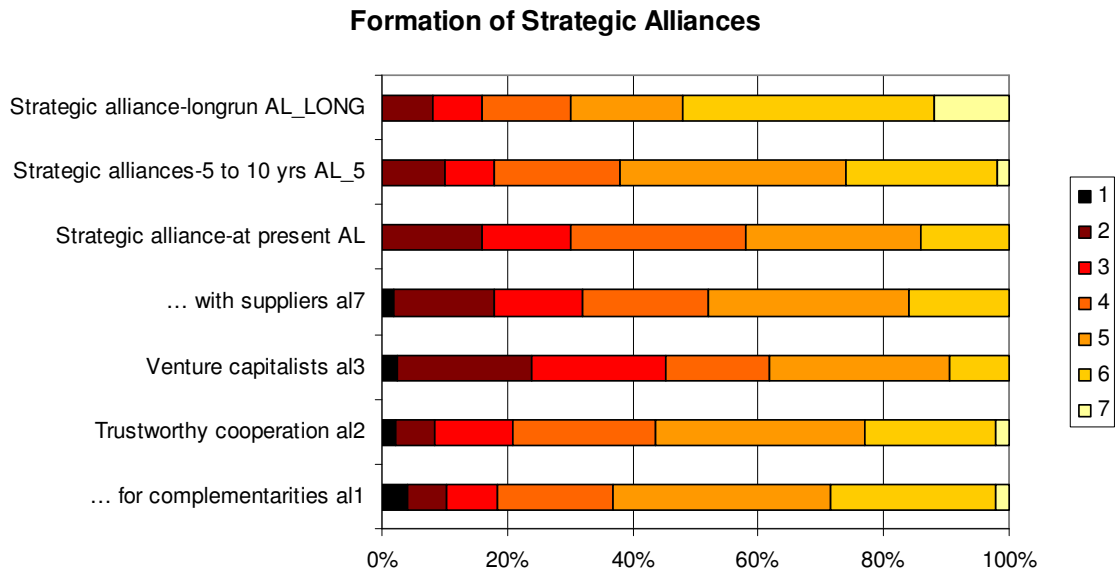
Most companies found it quite easy to integrate a diversity of specialist (*I1*) as the average score of 4.8 shows. The same could be said about the presence of people from differing professional disciplines (*I2*, average: 4.6). Still the lowest average score is received for the question concerning the implementation of mechanism that translate across different disciplinary languages (*I3*), where the average score is 4.1.

The average response from the general questions on organisational learning is 4.3 at the present, 5.2 “in the next 5 to 10 years” and 5.7 in the long-term perspective. The correlation with the average of the questions *I1* to *I12* is good with  $R^2$  values of 0.42 for the organizational learning at the present, 0.49 for 5 to 10 years from now and 0.40 for the long-term perspective. In the stepwise regression using questions *I1* to *I12* as predictors, the best fit was achieved by just using *I1* and *I9*, i.e. the ability to integrate specialist and the promotion of continuous improvement activities.

### **5.3 Formation of strategic alliances**

Section VIII of the questionnaire tries to measure the company’s ability to form strategic alliances with suppliers and customers in order to improve energy efficiency in buildings. The survey results are summarised in Figure 10.

The average score of question *al1* to *al4* is 4.25. It seems that the easiest is the formation of alliances that ensure strengths and complementarities of innovative capacity and know-how (*al1*) receiving an average score of 4.6. Finding partners for strategic alliances that can ensure trust, honesty, win/win commitment, good reputation (*al2*) also has a similar average response score (4.5). The possibility to influence suppliers to develop more energy efficient components for buildings (*al7*) receives an average of 4.1. The most difficult task seems to be to find venture capitalists supporting energy efficient new-construction (*al4*). The average response to this question is 3.8.



**Figure 10** Frequencies of responses to the question concerning the formation of strategic alliances. Scores range from 1 (very difficult) to 7 (very easy).

The average scores of the general questions on how easy or difficult it is to form strategic alliances to be able to construct energy efficient buildings are 4.1 at the moment, 4.6 in the next 5 to 10 years and 5.10 in the longer run. These correlate quite well with the average of the questions *al1* to *al4*, with  $R^2$  values of 0.45, 0.43 and 0.31 respectively. When the regression was performed on the specific questions the best fit was achieved using *al3* and *al7*, i.e. finding venture capitalist and the capability to influence suppliers, the  $R^2$  value was then 0.54.

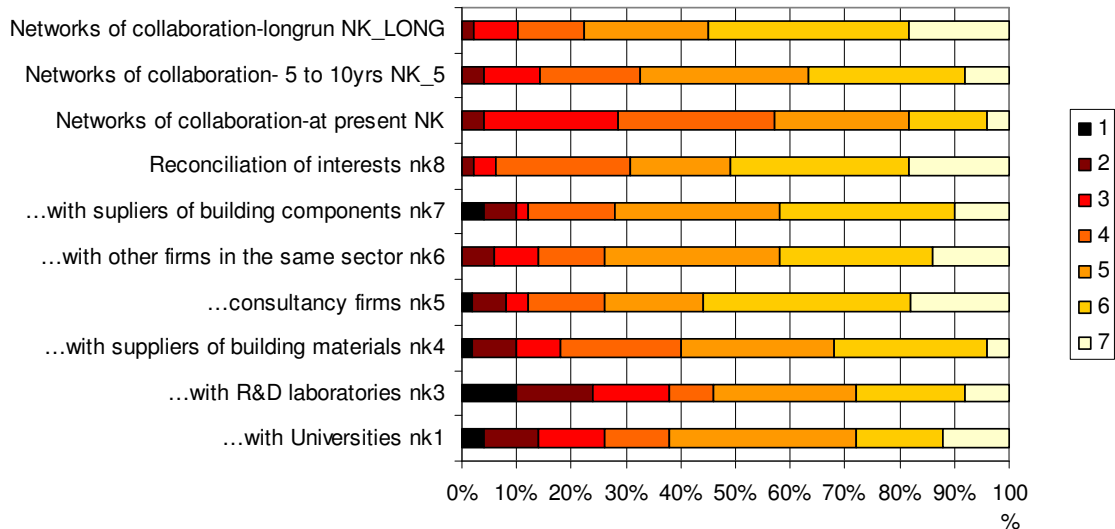
#### 5.4 Formation of networks of collaboration

The forth aspect of the control over innovation is the formation of networks of collaboration to be able to produce energy efficient buildings. The distribution of the scores of the responses to the questions assessing this aspect is found in Figure 11.

The average of the scores of the responses to questions *nk1* to *nk8* is 4.9. An average score above 5 is received for collaboration with consultancy firms (*nk5*, average: 5.3), with firms in the same sector (*nk6*, average: 5.1), and to the question of how relevant it is to reconcile the diverse interest and agendas of the actors involved in the building process

(*nk8*, average: 5.3). Establishing networks with suppliers of building components for product integration (*nk7*) has an average response score of exactly 5.

### Formation of networks of collaboration



**Figure 11** Frequencies of responses to the question concerning the formation of networks of collaboration. Scores range from 1 (very unlikely) to 7 (very likely).

It seems to be slightly harder to establish networks of collaboration with suppliers of building materials (*nk4*, average: 4.7), with Universities (*nk1*, average: 4.6) and with R&D laboratories (*nk3*, average: 4.2).

There is a general optimism in the ability to establish networks of collaboration, since the average scores to the response to the general questions are 4.3 at the moment, 4.9 in the next 5 to 10 years and 5.4 in the longer run. The correlation between the general questions and the more specific questions *nk1* to *nk8* is quite good and increases as the time perspective increases ( $R^2$  values are 0.37 at the moment, 0.53 in the next 5 to 10 years, and 0.54 in the longer run). A regression to the specific question does not give any better model for the general question about network collaborations at the moment. The best model is achieved by using *nk3*, *nk1*, *nk7* ( $R^2$  value of 0.32). These are the three collaboration alternatives that received the lowest average scores. This could be interpreted that the general perception is more formed by the more difficult collaborations

then the easy ones. In the midterm perspective the best fit is achieved by using as predictors the answers to question *nk8*, *nk3*, *nk6*, *nk5* ( $R^2$  value of 0.53).

### 5.5 Control over innovation – a summary

A question about the general capacity of the company to produce energy efficient buildings was also posed, while in the previous sections the different dimensions of control over innovation, i.e. technical capability (TC), organisational learning (L), the formation of strategic alliances (AL), and the capacity to form networks of collaboration (NK) were assessed separately. We now try to see how well the general question on control over innovation corresponds with the four dimensions. To do this we perform a regression where the general question on capacity (C) is the dependent variable and the response to the general question on technical capability (TC), organisational learning (L), strategic alliances (AL) and networks of collaboration (NK) are the predictors. This is done for each respective time period. The results can be seen in table 3.

**Table 3** Regression of the control over innovation in the production of energy efficient buildings on the technical capability, organizational learning, strategic alliances and networks of collaboration (unstandardised coefficients)

Variables	Control over innovation		
	At present	5 to 10 years	In the long run
Mean of TC <sup>2</sup> , L, AL, NK <sup>3</sup>	0.77***	0.80***	0.82***
Constant	0.89	0.95	1.01
$R^2$	0.29	0.46	0.63

\*\*\* $p < 0.001$

The  $R^2$  value of “at present” is rather low but the coefficient is still significant and quite close to 1. For the other two time perspectives the  $R^2$  value is quite high and the coefficient highly significant and close to 1. For the momentary value a regression was

<sup>3</sup> Each independent variable for the respective time horizon of the dependent variable.

also made to each of the responses, resulting in a much better  $R^2$  value of 0.42. But not all coefficients were significant so a stepwise regression was also made. The most important coefficient turned out to be organisational learning and networks of collaboration ( $R^2$  value: 0.43).

## 6 Engagement in the production of energy efficient buildings as specified by the behavioural model

### 6.1 Validity of the behavioural model at level 2

In the methodology section we presented a behavioural model based on three main determinants, i.e. 'attitude', 'social norm' and 'control over innovation'. The next step was to, in sections 3 to 5, see how the specific questions on the level 4 (see Figure1) could be represented by the domain questions on level 3 (e.g. ER, EV, MP, and so on). It was not always the case that the domain questions represented all the specific questions, but in these cases the most significant questions were identified. We then also made sure that the domain questions on level 3 made significant contribution to the main determinants at level 2 (i.e. ER and EV to A; MP, CP and RP to P; and TC, L, AL and NW to C). To conclude the validity of the behavioural model we now analyze the validity of the two hypotheses from section 2.

The first hypothesis ( $H_1$ ) states that the firm's willingness to engage in a clean technology or in this case in the production of energy efficient buildings, can be explained in terms of attitude (A), social pressure (SP) and control over innovation (C) according to the following equation:

$$H_1: I \sim W = w_0 + w_1A + w_2P + w_3C \quad (4)$$

In order to test the hypothesis, the (dependent) variable  $I$  (I4) is subjected to a linear regression on the (independent) variables A, P and C for the three time periods.

**Table 4** Regression of the willingness to produce energy efficient buildings on the corresponding attitude, social pressure and innovation control (unstandardised coefficients)

Variables	Willingness to engage		
	At present	5 to 10 years	In the long run
Attitude A	<b>0.72 (0.14)***</b>	<b>0.56 (0.14)***</b>	<b>0.39 (0.11)**</b>
Social pressure P	<b>-0.01 (0.1)</b>	<b>0.17 (0.1)</b>	<b>0.23 (0.08)**</b>
Control over innovation C	<b>0.28 (0.1)**</b>	<b>0.25 (0.1)*</b>	<b>0.26 (0.08)**</b>
Constant	<b>0.25 (0.79)</b>	<b>0.55 (0.73)</b>	<b>1.03 (0.64)</b>
R <sup>2</sup>	<b>0.46</b>	<b>0.47</b>	<b>0.54</b>

\*p<0.05;\*\*p<0.01;\*\*\*p<0.001

In all the three time periods at least two coefficients of the dependent variable were significant ( $p < 0.05$ ) and so, the null hypothesis stating that no dependent variable makes a significant contribution (i.e.  $w_1 = w_2 = w_3 = 0$ ) can be rejected. However since in both the present time period and in the 5 to 10 year period there was an insignificant variable, i.e. social pressure, working at this level with the model and using only the significant variables would exclude all level-3 variables related to social pressure even if these might be significant at a higher level. We will therefore now check the second hypothesis.

## 6.2 Validity of hypothesis H<sub>2</sub> and reliability of its variables

The second hypothesis (H<sub>2</sub>) states that perceived environmental risk (EV), economic risk (ER), community pressure (CP), market pressure (MP), regulatory pressure (RP), technological capability (TC), organisational learning (L), strategic alliance formation (AL) and networks of collaboration (NK) consistently contribute to attitude, social pressure and control over innovation and, eventually, to the firm leader's willingness to engage in the development or adoption of a new, cleaner technology, in this case the production of energy efficient technologies. The hypothesis can be expressed through the following equation (5):

$$H_2: I \sim W = w_0 + w_1EV + w_2ER + w_3CP + w_4MP + w_5RP + w_6TC + w_7L + w_8AL + w_9NK \quad (5)$$

To be able to test the hypothesis, the (independent) variable  $I$  is again subjected to a linear regression, this time all level-3 variables are the independent variables and again the three time periods are treated.

**Table 5:** Stepwise regression of the willingness to produce energy efficient buildings on the corresponding driving forces and barriers specified at level 3 (final step, unstandardised coefficients).

Variables	Willingness to engage		
	At present	5 to 10 years	In the long run
<b>Environmental risk, EVRindex</b>	<b>0.26 ±0.13 (0.06)</b>	-	-
<b>Economic risk, ER</b>	<b>0.68±0.14 (0.00)</b>	<b>0.67±0.13 (0.00)</b>	<b>0.31±0.10 (0.004)</b>
<b>Regulatory pressure, RP</b>	<b>-0.22±0.1 (0.03)</b>	<b>-0.23±0.1 (0.03)</b>	-
<b>Technical capabilities, TC2</b>	<b>0.23±0.12 (0.06)</b>	<b>0.32±0.1 (0.002)</b>	<b>0.21±0.1 (0.05)</b>
<b>Organisational learning, L</b>	<b>0.24±0.16 (0.15)</b>	-	-
<b>Networks of collaboration, NK</b>	<b>-0.21±0.13 (0.13)</b>	-	<b>0.22±0.9 (0.02)</b>
<b>Constant</b>	<b>1.43±0.74 (0.06)</b>	<b>1.71±0.61 (0.01)</b>	<b>1.93±0.52 (0.001)</b>
<b>R<sup>2</sup> (non adjusted)</b>	<b>0.50 (0.57)</b>	<b>0.56 (0.59)</b>	<b>0.58 (0.61)</b>

Significance in parentheses; threshold:  $p < 0.3$

As shown in Table 5, at least one coefficient is highly significant ( $p < 0.05$ ) in each case, thus the null hypothesis can be rejected and, accordingly, hypothesis  $H_2$ , can be confirmed.

The upper significance of 0.3 was used in all three cases giving varied results. For the “at present” case six variables were found to make a significant contribution, while in the other two time periods only three. All attempts to include more variables only decreased the adjusted  $R^2$  values and the significance of some variables. The correlation matrices for the significant variables in all cases showed values below 0.6, indicating that multicollinearity is not a problem and, thus, that the variables measure different dimensions of the willingness to produce energy efficient buildings.

In all three cases technical capabilities (TC) and economic risk perception (ER) are significant aspects of the willingness to engage in the production of energy efficient buildings. These results seem very plausible and correspond well with the results from the interviews. For the “at present” and the “5 to 10 years” case the main drivers are technical capabilities, economic risk perception and regulatory pressure. Regulatory pressure has a negative coefficient which seems slightly hard to understand, more then from the perspective that if energy efficiency is enforced from authorities the firms own willingness to produce energy efficient buildings decreases. Still we find it hard to believe that more energy efficient buildings would be built if the regulatory pressure would decrease.

Other contributions to the willingness “at the present” are the perceived environmental risk (EVRindex), the capability to perform networks of collaboration (NK) and organisational learning.

According to the model the regulatory pressure becomes insignificant in the long run while the ability to form networks of collaboration instead becomes significant, this time with a positive coefficient.

Since the correspondence between the questions at level 4 and the domain questions at level 3 was not always very good, the hypothesis  $H_2$  can also be explained by the accumulated connotative load of the domain scales as the following equation expresses:

$$H_{2a}: I \sim W = w_0 + w_1 \Sigma ev + w_2 \Sigma er + w_3 \Sigma cp + w_4 \Sigma mp + w_5 \Sigma rp + w_6 \Sigma tc + w_7 \Sigma l + w_8 \Sigma al + w_9 \Sigma nk \quad (6)$$

**Table 6** Stepwise regression of willingness to produce energy efficient buildings against the behavioral domain scales (i.e  $\Sigma ev$ ,  $\Sigma er$ ,  $\Sigma cp$ ,  $\Sigma mp$ ,  $\Sigma rp$ ,  $\Sigma tc$ ,  $\Sigma l$ ,  $\Sigma al$ ,  $\Sigma nk$ ) (final step, unstandardised coefficients)

Variables	Willingness to engage	
	At present	5 to 10 years
Economic risk, $\Sigma er$	-0.035±0.013 (0.009)	-0.029±0.10 (0.007)
Regulatory pressure, $\Sigma rp$	-	0.010±0.009 (0.29)
Technical capabilities, $\Sigma tc$	0.03±0.015 (0.05)	-
Organisational learning, $\Sigma l$	0.021±0.017 (0.23)	0.017±0.011 (0.12)
Strategic alliances, $\Sigma al$	-0.78±0.049 (0.12)	-
Networks of collaboration, $\Sigma nk$	0.04±0.023 (0.11)	0.046±0.018 (0.014)
Constant	4.16±1.26 (0.002)	4.04±1.01 (0.000)
<b>R<sup>2</sup> (non adjusted)</b>	<b>0.33 (0.4)</b>	<b>0.36 (0.41)</b>

Significance in parentheses; threshold:  $p < 0.3$

The same independent variables were used, since no distinction in time horizons have been made for these questions

The  $R^2$  values are lower in this model, but at least one of the coefficients is highly significant ( $p < 0.05$ ) in both cases, leading to the conclusion that the null hypothesis can

be rejected. The results are slightly different even if certain significant variables are the same. For the “at present” case economic risk perception and technical capabilities are the most significant domains, a result that is similar to the results of the regression based on the previous hypothesis. The fact that in this case the coefficient of the economic risk perception is negative can be explained by the inversion of the semantics, i.e. 7 represents high risk instead of low risk. Even capability to perform networks and organisational learning were significant in the previous model. The new variable in this case is the capability to form strategic alliances.

In the 5 to 10 year perspective the networking capabilities and economic risk perception are the most significant variables. Considerable contribution also comes from organisational learning and regulatory pressure. Giving a slightly different picture but still with two variables being represented in both cases, i.e. economic risk perception and regulatory pressure.

Summarising one can say that social pressure gives the weakest contribution with the exception of regulatory pressure. Most important for the willingness to produce energy efficient buildings is the control over innovation, specifically the technological capabilities but even networking and learning have an influence. Perceived economic risk and to a minor extent environmental risk perception, by forming the attitude also contribute to the firm’s willingness to engage in the production of energy efficient buildings. Due to higher  $R^2$  values the model based on hypothesis  $H_2$  is used, thus the results from table 5 are used to transform equation 5 into the following models representing the willingness to produce energy efficient buildings:

At present:

$$I \sim W = 1.43 + 0.26EV + 0.68ER - 0.22RP + 0.23TC + 0.24L - 0.21NK \quad (6)$$

The next 5 to 10 years:

$$I \sim W = 1.71 + 0.67ER - 0.23RP + 0.32TC \quad (7)$$

In the long run:

$$I \sim W = 1.93 + 0.31ER + 0.21RP + 0.22NK \quad (8)$$

These results are based on all the respondents, ranging from construction companies to housing companies. As can be seen from Figure 2 these actors play different roles in the building sector and thus their perception of barriers and drivers might differ. In order to find more homogenous groups we have chosen to first look at the architects and construction companies separately and thereafter housing companies alone.

### 6.3 A model representing the specific willingness of construction companies and architects to engage in the production of energy efficient buildings

The building sector is a complex sector with many different actors with various perceptions and attitudes. In the previous sectors these have been analysed together which might have lead to a spreading of the results. In this section we choose instead to focus on only representatives from construction companies and architects, since these cooperate for the construction of energy efficient buildings and can be seen both as adopters of energy efficient technology and developers of new construction concepts to save energy (see discussion in section 2.4). The results of the regression are seen in table 7.

**Table 7** Stepwise regression of the willingness to produce energy efficient buildings for developers and manufacturers on the corresponding driving forces and barriers specified at level 3 (final step, unstandardised coefficients).

Variables	Willingness to engage		
	At present	5 to 10 years	In the long run
<b>Economic risk, ER</b>	<b>0.55±0.25(0.052)</b>	-	-
<b>Community pressure, CP</b>	<b>0.22±0.196(0.285)</b>	-	-
<b>Regulatory pressure, RP</b>	<b>0.27±0.19(0.185)</b>	<b>0.33±0.20(0.13)</b>	<b>0.35±0.22(0.13)</b>
<b>Technical capabilities, TC2</b>	<b>0.70±0.12(0.000)</b>	<b>0.4±0.27(0.17)</b>	<b>0.26±0.22(0.25)</b>
<b>Organisational learning, L</b>	-	<b>0.87±0.45(0.075)</b>	<b>0.60±0.44(0.20)</b>
<b>Strategic alliances, AL</b>	-	<b>-0.88±0.31(0.015)</b>	<b>-0.62±0.36(0.11)</b>

<b>Networks of collaboration,</b>			
<b>NK</b>	<b>-0.48±0.17(0.018)</b>	<b>0.30±0.22(0.21)</b>	<b>0.59±0.29(0.064)</b>
<b>Constant</b>	<b>0.03±1.12(0.98)</b>	<b>0.07±1.57(0.97)</b>	<b>-0.67±1.68(0.7)</b>
<b>R<sup>2</sup> (non adjusted)</b>	<b>0.70 (0.79)</b>	<b>0.61 (0.73)</b>	<b>0.55 (0.68)</b>

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Significance in parentheses; threshold: p<0.3

We see here that the R<sup>2</sup> values are higher, despite a smaller sample group of “only” 18 respondents, for this regression and at least two coefficients are significant at the 5% level (p<0.05). Similarities with the previous model are the fact that economic risk perception and technical capabilities remain highly significant, at least at the “at present” case. Economic risk perception makes no significant contribution in the future cases, while the dimension “technological capabilities” continues to be of importance. Regulatory pressure is important in all three cases and in this case its coefficient is positive, which is easier to understand intuitively.

The results from table 7 can then be used, as in the general case, to create a model of the willingness to engage in the production of energy efficient buildings, in this case only for the developers and manufacturers. The models are represented by the following equations:

At present:

$$I\sim W=0.03 + 0.55ER + 0.22CP + 0.27RP + 0.70TC - 0.48NK \quad (9)$$

The next 5 to 10 years:

$$I\sim W=0.07 + 0.33RP + 0.4TC + 0.87L - 0.88AL + 0.30NK \quad (10)$$

In the long run:

$$I\sim W= - 0.67 + 0.35RP + 0.27TC + 0.60L - 0.62AL + 0.59NK \quad (11)$$

#### **6.4 A model representing the specific willingness of housing companies to increase the energy efficiency in buildings**

Within the building sector the housing companies can be seen as the final adopters of the energy efficient buildings (see Figure 2). A separate regression for these was made and the results can be seen in table 8.

**Table 8** Stepwise regression of the willingness to increase energy efficiency in buildings for housing companies on the corresponding driving forces and barriers specified at level 3 (final step, unstandardised coefficients).

Variables	Willingness to engage		
	At present	5 to 10 years	In the long run
<b>Environmental risk,</b>			
<b>EVRindex</b>	<b>-0.60±0.16(0.004)</b>	-	-
<b>Economic risk, ER</b>	<b>0.60±0.12(0.000)</b>	<b>0.60±0.11(0.000)</b>	<b>0.24±0.11(0.4)</b>
<b>Market pressure, MP</b>	<b>-0.38±0.12(0.012)</b>	-	-
<b>Regulatory pressure, RP</b>	<b>-0.34±0.07(0.000)</b>	<b>-0.48±0.12(0.002)</b>	-
<b>Technical capabilities, TC</b>	<b>-0.12±0.09(0.20)</b>	<b>0.24±0.13(0.09)</b>	-
<b>Organisational learning, L</b>	<b>0.61±0.13(0.001)</b>	-	<b>0.31±0.17(0.09)</b>
<b>Strategic alliances, AL</b>	-	-	<b>0.13±0.11(0.23)</b>
<b>Networks of collaboration,</b>			
<b>NK</b>	<b>0.56±0.11(0.000)</b>	<b>0.24±0.14(0.10)</b>	-
<b>Constant</b>	<b>1.26±0.55(0.045)</b>	<b>2.65±0.68(0.002)</b>	<b>2.06±0.61(0.005)</b>
<b>R<sup>2</sup> (non adjusted)</b>	<b>0.92 (0.95)</b>	<b>0.84 (0.88)</b>	<b>0.69(0.74)</b>

Significance in parentheses; threshold:  $p < 0.3$

For this segment the fit is much better as can be noted through the higher  $R^2$  values and the majority of the coefficients are highly significant ( $p < 0.05$ ). The reason for a better fit may be that this is a more homogeneous group of respondents.

The three most significant dimension for the “at present” case are economic risk perception, regulatory pressure and networks of collaboration. Compared to the “developers” technical capabilities loses in significance and is here seen as a barrier instead, while market pressure becomes more important even if this is seen as a barrier as well.

The willingness to increase energy efficiency in buildings for adopters in the form of housing companies can as in the previous cases be expressed through a model, by constructing three equations (12, 13, and 14) using the coefficients from table 8. The three equations are:

At present:

$$I\sim W=1.26 - 0.60EV + 0.60ER - 0.38MP - 0.34RP - 0.12TC + 0.61L + 0.56NK \quad (12)$$

The next 5 to 10 years:

$$I\sim W=2.65 + 0.60ER - 0.48RP + 0.24TC + 0.24 NK \quad (13)$$

In the long run:

$$I\sim W=2.06 + 0.24ER + 0.31L + 0.13AL \quad (14)$$

## 7 Simulation and specification of useful means of political interventions

In the preceding section, the statistical analysis of the survey results presented in sections 3 to 5 gave rise to models (specified in equations 6 to 14) that may allow for a prediction of the willingness of companies in the buildings sector in general to engage in the production of energy efficient buildings now and in the future. In the following, these models will be used to simulate different points of departure for political intervention and their effect on the technology-related behaviour. The results of this assessment will be used to identify examples of efficient policies. Since the adoption of more than one political measure might be appropriate, this section will also give some hints to a temporal sequence of selected instruments.

### 7.1 Prioritization of different means of political intervention

When trying to identify the most effective points of intervention into the system of drivers and barriers governing the decision-making behaviour of leading managers in the field considered in this study, we first need to acknowledge two points. The first point is the contribution – the *weight* – of a specific behavioural aspect with regard to a decision pro or contra an engagement in the production of energy efficient buildings. This weight is reflected in the coefficients associated with each of the relevant behavioural variables in the equations 6 to 14 and provides a kind of gauge for the intensity of intervention needed to bring about a change in the corresponding drivers and barriers. If this weight, or coefficient, is (in absolute terms) large, then small changes in the respective drivers and barriers may be sufficient to cause major changes in the affected behaviour; if it is small, large changes may be necessary to cause the same effect.<sup>4</sup>

The second point is the possible range of change in the respective behavioural domain. So, if a certain driver is known to be decisive for the corresponding behaviour to be

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<sup>4</sup> Note, however, that the intensity of intervention as it is used here refers to the relation between the change of perception of the cause (e.g. technical control) and the subsequent change of the effect (i.e. willingness to engage). It does not account for difference in the effort (e.g. R&D support) necessary to influence the causing effect in the first place.

shown and this driver is already in plentiful supply, then further increase in supply or amplification may hardly be possible – the *room for manoeuvre* is low. Conversely, a large difference between the actual and the “optimal state” of a driver or barrier gives rise to a large room for manoeuvre. In the model presented here, this room for manoeuvre is represented by the difference between the actual mean scores on the scale under consideration and the relevant potential maximum or minimum (i.e. the relevant endpoint) of the scale. In the present case, a score of 7 would be the optimum targets score in the case of a driver, a score of 1 in the case of a barrier.

When it eventually comes to prioritising the different measures, a lexicographic approach is applied in which the weight has clear priority. Unless the room for manoeuvre is indeed close to zero, a high-weight intervention always combines a given effect with minimum effort. The relevance of the room-for-manoevr aspect lies in the possibility to estimate the total effect achievable by a variety of measures and to avoid over-achievement in case of little room for manoeuvre.

In the following, the latter criteria will be applied to the analysis of the potentials of intervention into the behaviour of actors in the production of energy efficient buildings in general and developers and manufacturers of these buildings in particular.

## **7.2 Efficient support of the companies’ engagement in the production of energy efficient buildings in general**

The criteria to be used in the assessment of useful interventions to increase the production of energy efficient buildings are summarized in table 9. The weights of the behavioural domains are equivalent with the coefficients associated with the corresponding variables in table 5 as well in equations 6 to 8. The actual mean scores are calculated directly from the survey data, while optimum values follow the theoretical consideration that in order to maximize the total willingness to engage in the production of energy efficient buildings, positive contributions should be as high as possible and negative contributions as low as possible.

**Table 9** Criteria for assessing useful interventions into the production of energy efficient building in general

Criteria	Behavioural domains					
	EVR	ER	RP	TC	L	NK
<i>At present:</i>						
Weight	0.26	0.68	-0.22	0.23	0.24	-0.21
Actual score	1.6	3.8	4.1	4.1	4.3	4.3
<i>Next 5 to 10 yrs:</i>						
Weight	-	0.67	-0.23	0.32	-	-
Actual score	1.8	4.7	5.0	4.9	5.2	4.9
<i>In the long-run:</i>						
Weight	-	0.31	-	0.21	-	0.22
Actual score	2.1	5.3	5.7	5.6	5.7	5.4
Target score	7	7	1	7	7	1 (7)

According to the methodology explained in the previous section economic risk perception is the preferred starting point for intervention in all three time periods, having the highest rate and at least “at the present” quite a high manoeuvre. The other domains “at the present” have more or less the same weight, all around 0.2. If manoeuvre is also taken into consideration environmental risk perception has the largest one. Ranking the remaining 4 domains is not obvious, but if significance from table 5 is also taken into consideration then the order should be regulatory pressure, technical capabilities, organisational learning and last networks of collaboration. In “the next 5 to 10 years” the second preferred option is the technological capabilities and last regulatory pressure. In the long run technological capabilities and capacity to create networks of collaboration are more or less equal, but the significance of the capacity to create networks of collaboration is slightly higher. Table 10 shows the proposed sequence of interventions according to the rule developed in section 7.1 and the maximum aggregated effect achievable after each step in terms of engagement in energy efficient buildings.

**Table 10** Sequence of interventions and their respective effects on the engagement in the production of energy efficient buildings

	Starting point	Sequence of interventions					
<i>At present:</i>	I4a	(1) ER	(2) EV	(3) RP	(4) TC	(5) L	(6) NK
Specific effect*	4.7	2.2	1.4	0.7	0.7	0.6	0.7
Cumulated effect	4.7	6.9	8.3	9.0	9.6	10.3	11.0
<i>Next 5 to 10 yrs:</i>	I4b	(1) ER	(2) TC	(3) RP	-	-	-
Specific effect	5.4	1.5	0.7	0.9	-	-	-
Cumulated effect	5.4	6.9	7.6	8.5	-	-	-
<i>In the long-run:</i>	I4c	(1) ER	(2) NK	(3) TC	-	-	-
Specific effect	5.9	0.5	0.4	0.3	-	-	-
Cumulated effect	5.9	6.4	6.8	7.1	-	-	-

\*Specific effect = weight\*(target score-actual score)

The combination of interventions gives the possibility to achieve effects that are much larger than single interventions. By using all the cases one manages to achieve a maximum willingness that is more than double the original one (I4a) in the “at present” case and significant increase in the future cases.

### **7.3 Efficient support of the construction companies and architectures engagement in the production of energy efficient buildings**

In this section we apply the same methodology as in section 7.2 but in on only the construction companies and architectures. The results are summarised in table 11. In this case the weights are instead gathered form table 7 and equations 9 to 11 in section 6.3. The actual mean scores are calculated from the survey data related to the construction companies and architects while the optimum value follows the same logic as in the previous case, that in order to maximize the total willingness to engage in the production of energy efficient buildings positive contributions should be as high as possible and negative contribution as low as possible.

**Table 11** Criteria for assessing useful interventions into the production of energy efficient buildings for construction companies and architects

Criteria	Behavioural domains						
	ER	CP	RP	TC	L	AL	NK
<i>At present:</i>							
Weight	0.55	0.22	0.27	0.7	-	-	-0.48
Actual score	3.5	4	3.61	4.06	-	-	4.33
<i>Next 5 to 10 yrs:</i>							
Weight	-	-	0.33	0.4	0.87	-0.88	0.3
Actual score	-	-	4.56	4.83	5.06	4.56	4.89
<i>In the long-run:</i>							
Weight	-	-	0.35	0.26	0.6	-0.62	0.59
Actual score	-	-	5.33	5.5	5.56	5.06	5.33
Target score	7	7	7	7	7	1	1 (7)

For the “at present” case the technical capabilities is the domain in which the least effort will produce the largest effect, thereafter environmental risk perception and the capability to perform networks of collaboration (even if this one is negative). Regulatory pressure gives a slightly higher effect than community pressure. The manoeuvre is more or less equal in all cases. For the mid-term future perspective strategic alliances and organisational learning give the major effects, followed by technical capabilities and in the end regulatory pressure and networking capabilities at more or less the same level. Even in the long-term perspective the strategic alliances and organisational learning give the largest effect even if networking follows shortly thereafter. Regulatory pressure is followed by the technical capabilities. The sequence of interventions in terms of maximum effect (based on weight) and the aggregated effect can be found in table 12.

**Table 12** Sequence of interventions and their respective effects on the engagement in the production of energy efficient buildings for construction companies and architects

	Starting point	Sequence of interventions				
<b><i>At present:</i></b>	I4a	(1) TC	(2) ER	(3) NK	(4) RP	(5) CP
Specific effect*	4,56	2,06	1,93	1,60	0,92	0,66
Cumulated effect	4,56	6,62	8,54	10,14	11,06	11,72
<b><i>Next 5 to 10 yrs:</i></b>	I4b	(1) AL	(2) L	(3) TC	(4) RP	(5) NK
Specific effect*	5,33	3,13	1,69	0,87	0,81	0,63
Cumulated effect	5,33	8,46	10,15	11,02	11,82	12,46
<b><i>In the long-run:</i></b>	I4c	(1) AL	(2) L	(3) NK	(4) RP	(5) TC
Specific effect*	5,94	2,52	0,86	0,99	0,58	0,39
Cumulated effect	5,94	8,46	9,32	10,31	10,89	11,28

\*Specific effect = weight\*(target score-actual score)

In this case we see an increased maximum effect even in the future perspectives. In all three the willingness to engage in energy efficient buildings is doubled.

#### **7.4 Efficient support of housing companies engagement in energy efficient buildings**

Just as for the case of developers we use the methodology used in section 7.2 and apply it only to housing companies. The results can be seen in table 13. The weights used are taken from table 8 and equations 12 to 13 in section 6.4. The actual mean scores are calculated from the responses to the survey of the housing companies and the optimum follows the same logic as in the previous sections (see e.g. section 7.2).

**Table 13** Criteria for assessing useful interventions into the production of energy efficient buildings for construction companies and architects

Criteria	Behavioural domains							
	EV	ER	MP	RP	TC	L	AL	NK
<i>At present:</i>								
Weight	-0,6	0,6	-0,38	-0,34	-0,12	0,61	-	0,56
Actual score	1,55	3,78	3,23	4,33	4,09	4,23	-	4,45
<i>Next 5 to 10 yrs:</i>								
Weight	-	0,6	-	-0,48	0,24	-	-	0,24
Actual score	1,8	4,57	4,59	5,25	4,86	5,09	-	5,14
<i>In the long-run:</i>								
Weight	-	0,24	-	-	-	0,31	0,13	-
Actual score	2,18	5,26	5,5	5,96	5,55	5,73	5,22	5,64
Target score	1	7	1	1	1	7	7	7

To change the attitude in housing companies towards energy efficient buildings with the least effort addressing the issue of organisational learning should be prioritized. The next step is to reduce the economic risk, directly followed by the perceived environmental risk perception.

**Table 14** Sequence of interventions and their respective effects on the engagement in energy efficient buildings for housing companies

	Starting point	Sequence of interventions						
	I4a	(1) L	(2) ER	(3) EV	(4) NK	(5) MP	(6) RP	(7) TC
<i>At present:</i>								
Specific effect*	4,61	1,69	1,93	0,33	1,43	0,85	1,1322	0,3708
Cumulated effect	4,61	6,30	8,23	8,56	9,99	10,84	11,97	12,34
<i>Next 5 to 10 yrs:</i>								
Specific effect	5,26	1,46	2,04	0,51	0,45	-	-	-
Cumulated effect	5,26	6,72	8,76	9,72	9,20	-	-	-
<i>In the long-run:</i>								
Specific effect	5,87	0,39	0,42	0,23	-	-	-	-
Cumulated effect	5,87	6,26	6,68	6,91	-	-	-	-

The largest effect on the willingness is observed for the “at present” case, this is not surprising since there are more domains that make a significant impact and since the manoeuvre is larger in this case.

## **7.5 Identification of suitable instruments of political support**

To be able to assess the suitable instruments that can be derived from the results in the previous section it is important to state that the questionnaire addresses the willingness to engage in energy efficient buildings of various actors, thus only provide one “piece of the puzzle”. A second observation is that for this case study, i.e. energy efficiency in buildings, the distinction between developers and adopters is not as straightforward as in other cases as discussed in section 2.4. A design of policy instruments has to take into consideration this dynamic and the fact that various barriers and drivers can play different roles for different actors and over different time-spans. These can also be related to the concept of the learning curve where initial investments are made by the early developers and adopters. For these actors, support of the technical capabilities and the reduction of economic risks are important in the beginning as the survey results show. With the passing of time, the ability to ensure that gained capacities within the sector in general are shared both between various actors (the importance of AL) and within the company (L), become the key issues instead. For the adopters, i.e. the housing companies, organisational learning and economic risk appear to be the most important areas to improve the willingness to engage. Organisational learning is hard to handle from a policy perspective since it is inherent in the company’s management structure and lies outside the political action range. In the case of adopters markets pressure also becomes a dimension for possible action.

Examples of possible policy measures that may contribute to increased learning and willingness to engage are creations of networks, support of demonstration projects, information schemes, and workshops. Experiences in Germany point at successful measures to reduce economic risk for the engagement in “passive houses”, one of them being a fixed rent below market level. Economic risk can also be taken by the State instead of private actors, as is the case for public procurement. The results from our study suggest that these examples of policies might have an impact on the production of energy efficient buildings, but to fully analyse a policy intervention other issues such as cost-effectiveness have to be taken into account as well. As presented in the next chapter further analysis will be presented in the coming work packages.

## 8 Outlook

As mentioned at the beginning of chapter 7 this report only illustrated the results from an intermediate state of the more extensive work of finding appropriate policy interventions that can result in the construction of more energy efficient buildings. The aim of work package 2 has been to assess the willingness of the actors in the building sector towards energy efficiency in buildings, in order to be able to identify some key drivers and barriers. From these barriers and drivers a first review of possible policy instruments with respect to the key stakeholder and the time of intervention. This review is far from being comprehensive and should be considered more as possible examples. There are also barriers and drivers in the process from willingness to pure action. A more comprehensive assessment of possible policy instruments that also takes into consideration other research results must be done. This assessment is the aim of the following work package 3. The results will then be presented, discussed and validated at an expert workshop (work package 4). The results from all the case studies will then be combined to form a synthesis report (work package 5). In the final step this report will be discussed at an international workshop (work package 6).

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## Annex 1

# Questionnaire Energy Efficiency in Buildings

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The questionnaire is divided in 10 sections dealing with different aspects of your engagement in the production of energy efficient buildings. Please note that in all cases you – the respondent – are asked for your **personal** estimation.

### Information for filling the questionnaire:

When responding to the questions, please tick the box with the answer that fits your personal estimation best. In sections II to X, you have the choice between seven boxes for every question. These boxes represent a scale that reaches from the attribute on the left-hand side to the attribute on the right-hand side. For example, the boxes of the line

Very unlikely        Very likely

correspond to the following ratings (from left to right):

- 1 – very unlikely
- 2 – fairly unlikely
- 3 – slightly unlikely
- 4 – uncertain
- 5 – slightly likely
- 6 – fairly likely
- 7 – very likely

Please, tick only **one box** per question!!!

The box 'Not applicable' found in most questions can be ticked if from your or your company's perspective the question does not make sense.

### Confidentiality

The information gathered in this survey will not be used for any other purpose than being processed for the research project. The data will be analysed statistically and the results will be revealed to a third party only as mean values or trends. This ensures **confidentiality** as, due to the large number of respondents, inference to specific responses is impossible.

Respondent's position in the firm	:	___
Number of employees of the firm	:	___

**Section I: General information**

- I.1 Concerning energy efficient buildings what do you regard as the main source of innovation on construction inputs in your company?*
- Our own R&D laboratories and human resources
- We transfer or license major parts of our product technology from other firms
- We often obtain new inputs and components for our product from our suppliers
- I.2 What do you regard as the main source of construction process innovations in your company?*
- Our own R&D laboratories and human resources
- We transfer or license major parts of our process technology from other firms
- We often obtain new inputs and components for our process from our suppliers
- I.3 What do you believe is the main feature that could describe the maturity of your construction inputs and materials?*
- Diversity of design, often customized
- At least one product is stable enough to have significant production volumes
- Undifferentiated standard products
- I.4 What do you believe is the main feature that describes the maturity of your construction process?*
- Flexible and not very efficient; major changes can be fairly easily accommodated
- More rigid, with changes occurring in major stages of the process
- Efficient, capital intensive; not flexible with high costs of change
- I.5 What are your research and development activities normally focused on?*
- Unspecified because of high degree of technical uncertainty
- On specific products or process features
- On incremental changes of product technology; emphasis on process technology
- I.6 Type of equipment used in your plant can be mainly described as:*
- General purpose, requiring skilled labour
- Some stages of the process are automated
- Special purpose, mostly automatic, labor focus on monitoring and servicing equipment
- I.7 The cost of changing construction process technologies for your company is likely to be*
- Low       Moderate       High
- I.8 The number of competitors in your industry is likely to be:*
- Few, but growing in number with widely fluctuating market share
- Declining in number

- Few companies that dominate the market
- I.9 *The major basis of the competitiveness of your company is:*
- Functional product performance   
 Product variation; fitness for use and differentiation   
 Price and/or quality
- I.10 *The organizational control in your company is mainly performed via:*
- Informal and entrepreneurial relations   
 Through project and task groups   
 Structures, rules and goals
- I.11 *The size of your company is:*
- Small  Medium   
 Large

- I.12 To what extent has your firm been engaged in innovation/construction towards energy efficient buildings in the past?
- Not at all        Extensively I don't Know
- I.13 To what extent is your firm presently engaged in innovation/construction towards energy efficient buildings?
- Not at all        Extensively
- I.14 To what extent does your firm plan to innovate/construct energy efficient buildings?
- Not at all        Extensively I don't Know

**Section II** The generation of residuals is a feature inherent to almost any industrial activity. This section intends to assess your perception concerning the nature of possible effects to the environment generated by the usage of energy in conventional buildings. *Tick only one box in each row.*

The environmental effects generated in the usage of energy in conventional buildings are likely to be:

- |      |                                  |                          |                          |                          |                          |                          |                          |                          |  |
|------|----------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--|
| Ev1  | Controllable                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Uncontrollable                             |
| Ev2  | Not threatening                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Very threatening                           |
| Ev3  | Of very local impact             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Of global impact                           |
| Ev4  | With no fatal consequences       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | With fatal consequences                    |
| Ev5  | Equally distributed              | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Affecting people very unequally            |
| Ev6  | Unproblematic                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Catastrophic                               |
| Ev7  | Not affecting future generations | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Affecting future generations very strongly |
| Ev8  | Completely legitimate            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Not legitimate at all                      |
| Ev9  | Not affecting me                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Affecting me                               |
| Ev10 | Arising with long delay          | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Arising immediately                        |
| Ev11 | Pure speculation                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Scientifically confirmed                   |

---

**II.1 The environmental problems generated by this company in our daily operations are likely to be...**

... at the moment: Negligible         Very dramatic

... in the next 5 to 10 years: Negligible         Very dramatic

... in the longer run: Negligible         Very dramatic

---

**II.2 The environmental effects generated in the usage and disposal of our products are likely to be...**

... at the moment: Very low         Very high

... in the next 5 to 10 years: Very low         Very high

... in the longer run: Very low         Very high

---

**II.3 As a consequence, for this firm improving energy efficiency in buildings is:**

... at the moment: Very irrelevant         Very relevant

... in the next 5 to 10 years: Very irrelevant         Very irrelevant

... in the longer run: Very irrelevant         Very irrelevant

---

**II.4 Our involvement in improving energy efficiency is likely to result in:**

Decrease in our competitiveness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Increase our competitiveness
No effect on public image	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Improve our public image
Minor environmental benefits	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Large environmental benefits
Negative effects on the growth of our firm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Positive effects on the growth of our firm
Major technological failure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Major technological success

**Section III** This section intends to assess the signals that your firm perceives from the marketplace to produce more energy efficient buildings.

---

**III.1 The pace of technological innovation in our sector is very rapid. Soon we will be moving towards the production of buildings with higher energy efficiency.**

Very unlikely         Very likely  Not applicable

**III.2 Our competitors are thinking of producing buildings with higher energy efficiency**

Very unlikely         Very likely  Not applicable

**III.3 A good proportion of our customers think that this company should produce buildings with higher energy efficiency**

Very unlikely         Very likely  Not applicable

**III.4 Our customers will be pushing us to produce buildings with higher energy**

efficiency.

Very unlikely        Very likely  Not applicable

III.5 Generally speaking, this company does what our customers think we should do regarding environmental issues.

Very unlikely        Very likely  Not applicable

III.6 The competition in our industry is very hostile creating unfavourable business climate and limited market opportunities. This will push us to produce buildings with higher energy efficiency.

Very unlikely        Very likely  Not applicable

III.7 The market for our firm is very heterogeneous, challenging our company to maintain a broad line of products to match the diversity of customers needs. This will push us to venture in the construction of energy efficient buildings.

Very unlikely        Very likely  Not applicable

III.8 The competition in our industry is very hostile creating unfavourable business climate and limited market opportunities. This hinders us from producing buildings with higher energy efficiency.

Very unlikely        Very likely  Not applicable

III.9 Customers lack enough knowledge about energy efficiency to create a demand for energy efficient buildings

Very unlikely        Very likely  Not applicable

---

III.10 In general it can be said that the signals (demand) that we perceive from the market place (example: customers, suppliers and competitors) telling us that we should produce buildings with higher energy efficiency are ...

... at the moment: Very weak        Very strong

... in the next 5 to 10 years: Very weak        Very strong

... in the longer run: Very weak        Very strong

---

**Section IV** This section gathers your opinion concerning the general demand of energy efficient buildings.

---

IV.1 Our most important shareholders think that our company should produce buildings with higher energy efficiency.

Very unlikely        Very likely  Not applicable

IV.2 In terms of public image it is important for our company to produce energy efficient buildings.

Very unlikely        Very likely  Not applicable

IV.3 Mass media reports (via radio, TV, newspapers, etc) will be pushing us to produce buildings with higher energy efficiency within the next five years.

Very unlikely        Very likely  Not applicable

IV.4 Our environmental advisors think that we should produce energy efficient buildings.

Very unlikely        Very likely  Not applicable

IV.5 Generally speaking, this company does what environmental consultants think that we should with regard to producing energy efficient buildings.

Very unlikely        Very likely  Not applicable

IV.6 The local and regional community will be pushing us to produce more energy efficient buildings within the next five years.

Very unlikely        Very likely  Not applicable

IV.7 Generally speaking, this company does what the local and regional community thinks that our company should do regarding environmental issues.

Very unlikely        Very likely  Not applicable

IV.8 The local community can lobby and pressure us to produce buildings with higher energy efficiency.

Very unlikely        Very likely  Not applicable

IV.9 Most of our important staff will be pushing to produce buildings with higher energy efficiency within the next five years.

Very unlikely        Very likely  Not applicable

IV.10 Generally speaking, this company does what our important staff think what we should do.

Very unlikely        Very likely  Not applicable

IV.11 There are several NGO's that will be pushing us to produce buildings with higher energy efficiency within the next five years.

Very unlikely        Very likely  Not applicable

IV.12 There are important pressure and interest groups that oppose the production of energy efficient buildings.

Very unlikely        Very likely  Not applicable

IV.13 Pressure and interest groups that oppose the production energy efficient buildings

have the power to delay such a process.

Very unlikely        Very likely

Not applicable

---

IV.14 In general, the pressure from the community (local and regional NGO's, universities & households associations, unions) that this company faces to produce energy efficient buildings is (will be)...

... at the moment: Very weak        Very strong

... in the next 5 to 10 years: Very weak        Very strong

... in the longer run: Very weak        Very strong

---

**Section V** This section intends to assess the demand of energy efficient buildings from diverse institutions.

V.1 The local public authorities (e.g. environmental, housing, buildings or planning authorities, municipalities) think that our company should produce buildings with higher energy efficiency.

Very unlikely        Very likely Not applicable

V.2 The local public authorities (e.g. environmental, housing, buildings or planning authorities, municipalities) will be pushing us to produce buildings with higher energy efficiency within the next five years.

Very unlikely        Very likely Not applicable

V.3 The local public authorities (e.g. environmental, housing, buildings or planning authorities, municipalities) have the capabilities to force us to produce buildings with higher energy efficiency

Very unlikely        Very likely Not applicable

V.4 Generally speaking this company does what the local public authorities (e.g. environmental, housing, buildings or planning authorities, municipalities) think that our company should do.

Very unlikely        Very likely Not applicable

V.5 The national authorities (e.g. environmental, housing, buildings or planning authorities) think that our company should produce buildings with higher energy efficiency.

Very unlikely        Very likely Not applicable

V.6 The national authorities (e.g. environmental, housing, buildings or planning authorities) will be pushing us to produce buildings with higher energy efficiency within the next five years.

Very unlikely        Very likely Not applicable

V.7 Generally speaking this company does what the national public authorities (e.g. environmental, housing, buildings or planning authorities) think that our company should do.

Very unlikely        Very likely Not applicable

V.8 The national authorities (e.g. environmental, housing, buildings or planning authorities) have the capabilities to force us to produce buildings with higher energy efficiency

Very unlikely        Very likely Not applicable

V.9 International agreements such as Kyoto will push us to produce buildings with higher energy efficiency within the next five years.

Very unlikely        Very likely Not applicable

V.10 EU directives such as the Directive on Energy Performance of Buildings will push us to produce buildings with higher energy efficiency.

Very unlikely        Very likely Not applicable

V.11 Generally speaking this company follows what the EU Directives prescribe.  
 Very unlikely         Very likely Not applicable

V.12 The EU Commission has the capabilities to force us to produce buildings with higher energy efficiency.  
 Very unlikely         Very likely Not applicable

V.13 Pre-empting the risk of future environmental liabilities will force us to produce buildings with higher energy efficiency  
 Very unlikely         Very likely Not applicable

V.14 Our decision of the level of investment in energy efficiency in the new construction is usually based on the National or regional building standards  
 Very unlikely         Very likely Not applicable

---

V.15 There are several regulatory institutions (e.g. EU Commission, our national authorities) pushing us to produce buildings with higher energy efficiency  
 ... at the moment: Very unlikely         Very likely  
 ... in the next 5 to 10 years: Very unlikely         Very likely  
 ... in the longer run: Very unlikely         Very likely

---

V.16 In general the social pressure (e.g. from the community, the market place, government agencies and public institutions, etc.) on this company to produce buildings with higher energy efficiency is (will be) ...  
 ... at the moment: Very low         Very high  
 ... in the next 5 to 10 years: Very low         Very high  
 ... in the longer run: Very low         Very high

---

V.17 Most people and institutions that are important for the success of our company think that we should produce buildings with higher energy efficiency.  
 ... at the moment: Very unlikely         Very likely  
 ... in the next 5 to 10 years: Very unlikely         Very likely  
 ... in the longer run: Very unlikely         Very likely

---

**Section VI** assesses your company's technological and organizational capabilities to develop or adopt the stationary fuel cell technology.

VI.1 Our company has the R&D capability to investigate the feasibility of energy efficient buildings.

Very unlikely        Very likely Not applicable

VI.2 We have the capabilities to build and test experimental prototypes of energy efficient buildings.

Very unlikely        Very likely Not applicable

VI.3 We can estimate the costs of improving energy efficiency in buildings.

Very unlikely        Very likely Not applicable

VI.4 We can assess technological feasibility (engineering) of improved energy efficiency.

Very unlikely        Very likely Not applicable

VI.5 This firm has enough slack resources to invest in innovative activities for the development of buildings with higher energy efficiency.

Very unlikely        Very likely Not applicable

VI.6 We can identify suppliers and procurement chains for key components and materials for the construction of energy efficient buildings:

Very unlikely        Very likely Not applicable

VI.7 In the construction of energy efficient buildings we can procure new equipment and machinery that *ensure* the minimization of waste and pollution in the production processes.

Very unlikely        Very likely Not applicable

VI.8 The compatibility of new energy saving technologies in buildings with current standards of materials and inputs for construction is:

Very low        Very high Not applicable

VI.9 The compatibility of construction processes inherent to new energy saving technologies in buildings with conventional construction is:

Very low        Very high Not applicable

VI.10 For our company, finding venture capitalists supporting the construction of energy efficient buildings is ...

Very difficult        Very easy Not applicable

VI.11 Our firm is technologically capable to produce "passive houses" (houses without need for conventional heating systems) that are sufficiently working to sell.

Very unlikely        Very likely Not applicable

VI.12 Our firm is technologically capable to produce houses with natural cooling systems (cooling without mechanical air conditioning) that are sufficiently working to sell.

Very unlikely        Very likely Not applicable

VI.13 Our firm is technologically capable to cut energy usage in existing buildings by:

Less than 10%         More than 70%  Not applicable

---

VI.14 We find that the level of knowledge available in the marketplace for our firm to engage in energy efficient new-construction is...

... at the moment: Very low         Very high

... in the next 5 to 10 years: Very low         Very high

... in the longer run: Very low         Very high

---

VI.15 In our firm the technological capabilities required to launch a product with high energy efficiency that meets our profit and/or business requirements are:

... at the moment: Very low         Very high

... in the next 5 to 10 years: Very low         Very high

... in the longer run: Very low         Very high

---

**Section VII** This section intends to assess the internal capability to integrate and generate new knowledge concerning energy efficiency.

VII.1 The integration of a diversity of specialties (professionals) to solve the problem of generating buildings with higher energy efficiency is for our firm.

Very difficult         Very easy  Not applicable

VII.2 We count with the necessary people that speak two or more professional languages and can see the world from two or more different professional perspectives.

Very unlikely         Very likely  Not applicable

VII.3 The implementation of mechanisms that translate across different disciplinary languages is for this firm:

Very difficult         Very easy  Not applicable

VII.4 We can minimize employee's individual opposition to learn new techniques and work practices.

Very unlikely         Very likely  Not applicable

VII.5 Most people within our firm value the experience of acquiring new skills and abilities.

Very unlikely         Very likely  Not applicable

VII.7 This firm can promote a wide participation in organization-wide continuous improvement activity towards the development of more energy efficient buildings.

Very unlikely         Very likely  Not applicable

VII.8 In this firm, experiences and knowledge generated in previous building projects for the development of new buildings are.

Very irrelevant         Very relevant  Not applicable

VII.9 In this firm, experiences and knowledge generated in previous projects are systematically transferred to new projects.

Very unlikely         Very likely  Not applicable

VII.10 In this firm, experiences and knowledge generated in low-energy demonstration projects are systematically transferred to the normal new-construction.

Very unlikely         Very likely  Not applicable

VII.11 Our company counts with the necessary capabilities to create and use new knowledge that enables the construction of energy efficient buildings.

... at the moment: Disagree very much         Agree very much

... in the next 5 to 10 years: Disagree very much         Agree very much

... in the longer run: Disagree very much         Agree very much

**Section VIII** This section intends to assess how easy it is for your company to perform strategic alliances with suppliers and customers in order to improve the energy efficiency of the new-construction.

VIII.1 Finding partners for strategic alliances that ensure strengths and complementarities of innovative capacity and know-how is...

Very difficult         Very easy  Not applicable

VIII.2 Concerning production of energy efficient buildings, finding partners for strategic alliances that ensure trust, honesty, win/win commitment, good reputation is...

Very difficult         Very easy  Not applicable

VIII.3 Finding venture capitalists supporting energy efficient new-construction is for our company. ...

Very difficult         Very easy  Not applicable

VIII.4 This firm has the capability to influence suppliers to develop more energy efficient components for our buildings. ...

Very difficult         Very easy  Not applicable

VIII.5 Our company finds that the forming of strategic alliances (with suppliers, customers or competitors) to enable the construction of energy efficient buildings is...

... at the moment: Very difficult         Very easy

... in the next 5 to 10  
years:

Very difficult         Very easy

... in the longer run:

Very difficult         Very easy

---

**Section IX** This section intends to assess your capabilities to perform networks of collaboration to produce energy efficient buildings

IX.1 Our company can establish networks of collaboration with Universities to out-source know-how and learn how to build energy efficient buildings.

Very unlikely        Very likely  Not applicable

IX.2 Our company can establish networks of collaboration public with R&D laboratories..

Very unlikely        Very likely  Not applicable

IX.3 Our company can establish networks of collaboration with suppliers of building materials for product integration.

Very unlikely        Very likely  Not applicable

IX.4 Our company can establish networks of collaboration with consultancy firms with expertise in energy efficiency.

Very unlikely        Very likely  Not applicable

IX.5 Our company can establish networks of collaboration with other firms in the same sector to transfer technology and expertise.

Very unlikely        Very likely  Not applicable

IX.6 Our company can establish networks of collaboration with suppliers of building components (e.g. ventilation systems) for product integration.

Very unlikely        Very likely  Not applicable

IX.7 In order to produce buildings with higher energy efficiency the reconciliation of diverse interest and agendas of the actors involved in the building process is:

Very irrelevant        Very relevant  Not applicable

IX.8 After assessing our capabilities to perform networks of collaboration it can be said that: Establishing networks of collaboration to acquire know-how for improving the energy efficiency for our company is (will be)...

... at the moment: Very difficult        Very easy

... in the next 5 to 10 years: Very difficult        Very easy

... in the longer run: Very difficult        Very easy

IX.9 In general, how much capacity has your company to produce energy efficient housing/buildings?

... at the moment: Very small        Very large

... in the next 5 to 10 years: Very small        Very large

... in the longer run: Very small        Very large

**Section X** In this section we would like to have your opinion about the benefits and risks that the production of energy efficient buildings may imply for your company.

X.1 Energy saving technologies have created a new market niche for our firm:

Very likely         Very unlikely  Not applicable

X.2 The R&D required to produce buildings with higher energy efficiency is likely to be:

Extremely minimal         Extremely great  Not applicable

X.3. The costs associated with this amount of R&D for our firm are likely to be:.

Extremely minimal         Extremely great  Not applicable

X.4 For our firm the advantages of pioneering energy saving technologies in buildings/housing are likely to be:

Extremely great         Extremely minimal  Not applicable

X.5 We believe that the venture of launching low energy buildings would be “ahead of its time” for our firm.

Disagree very much         Agree very much  Not applicable

X.6 In the production of energy efficient buildings (e.g. going beyond the building standards) our firm prefers to be a follower rather than a pioneer.

Disagree very much         Agree very much  Not applicable

X.7 Our costumers’ willingness to pay for a more expensive but more energy efficient building is likely to be:

Extremely great         Extremely minimal  Not applicable

X.8 What is the likelihood that your firm will have the necessary financial resources to produce buildings with higher energy efficiency?

Extremely great         Extremely minimal  Not applicable

X.9 What is the likelihood that your firm will have the necessary human and intellectual resources to produce buildings with higher energy efficiency?

Extremely great         Extremely minimal  Not applicable

X.10 What is the likelihood that the required investment for the production of buildings with higher energy efficiency affects positively the competitiveness of your company?

Extremely great         Extremely minimal  Not applicable

X.11 To what degree can low energy buildings compete against standard buildings in terms of comfort?

Very competitive         Very uncompetitive  Not applicable

X.12 If your company pioneers in the production of energy efficient buildings what is the likelihood that you may have substantial losses?

Very unlikely         Very likely  Not applicable

X.13 The certainty that a venture of producing a low energy building can be accomplished by our firm is...

Extremely minimal         Extremely great Not applicable

X.14 What is the likelihood that the extra investments needed to produce buildings with higher energy efficiency will be recuperated from the customers?

Extremely great         Extremely minimal Not applicable

X.15 To what degree can low energy buildings compete against standard buildings in terms of production costs?

Very competitive         Very uncompetitive Not applicable

X.16 For our firm the venture of producing buildings with higher energy efficiency seems to imply economically:

... at the moment: Great losses         Great benefits

... in the next 5 to 10 years: Great losses         Great benefits

... in the longer run: Great losses         Great benefits

X.17 For our company the engagement on the production of buildings with higher energy efficiency seems to imply:

... at the moment: Very bad consequences         Very good consequences

... in the next 5 to 10 years: Very bad consequences         Very good consequences

... in the longer run: Very bad consequences         Very good consequences

X.18 Our engagement in the construction of energy efficient buildings/housing seems to have for the environment:

... at the moment: No consequences         Very good consequences

... in the next 5 to 10 years: No consequences         Very good consequences

... in the longer run: No consequences         Very good consequences

X.19 The development and diffusion of energy saving technologies in buildings/housing seems to have for the energy sector:

... at the moment: No consequences         Very good consequences

... in the next 5 to 10 years: No consequences         Very good consequences

... in the longer run: No consequences         Very good consequences

X.20 After evaluating the outcomes, pressures and capabilities to construct buildings with higher energy efficiency, what is the likelihood that your firm will engage in the construction of buildings with higher energy efficiency?

... at the moment:                      Very unlikely                        Very likely

... in the next 5 to 10                      Very unlikely                        Very likely  
years:

... in the longer run:                      Very unlikely                        Very likely

**X.21 What is the likelihood that your firm will engage further in the development/usage of better energy saving technologies in your business activities in general?**

... at the moment:                      Very unlikely                        Very likely

... in the next 5 to 10                      Very unlikely                        Very likely  
years:

... in the longer run:                      Very unlikely                        Very likely

**Thank you very much for your cooperation!**

## Annex 2

### Reliability of data

To check to reliability of the data Cronbach reliability test ( $\alpha$ ) of scales was used.  
The average of the  $\alpha$  from the various domains is : 0,865.

Summary reliability test	
Attitude domains	$\alpha$
Environmental risk perception	0,930
Market pressure	0,765
Community pressure	0,882
Perceived regulatory pressure	0,924 (0,884)
Technical capabilities	0,892
Learning	0,922
Strategic alliances	0,872
Economic risk perception	0,705