DECISION MAKING PROCESSES AND THE ADOPTION OF ENERGY SAVING TECHNIQUES IN RESIDENTIAL AND COMMERCIAL REAL ESTATE

A.G. ENTROP Eng.[1]
H.J.H. BROUWERS Prof. Dr. Eng.[1]
G.P.M.R. DEWULF Prof. Dr.[1]
J.I.M. HALMAN Prof. Dr. Eng.[1]

[1] Department of Construction Management and Engineering, University of Twente, Enschede, Overijssel, The Netherlands, a.g.entrop@utwente.nl, h.j.h.brouwers@utwente.nl, g.p.m.r.dewulf@utwente.nl, j.i.m.halman@utwente.nl

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Summary

In this paper a research framework is presented for a better understanding of how actors take decisions on adopting and applying energy saving techniques in an inter-organisational context. Based on a literature study these actors are expected to be influenced by the network in which they operate during different phases of building projects and their expectations, partially based on experiences in the past, regarding the feasibility of the project's objectives. Because of different degrees of experience and social responsibility or accountability of individual actors in building projects, four different types of building projects are distinguished that cover a large part of all the building projects conducted. The characteristics of these four types are described for the Dutch situation. For two of them some first empirical results are given.

1. Introduction

The energy consumption in the built environment accounts for more than forty per cent of the total energy consumption in Europe (EC, 2002). Improving the energy performance of the built environment is an important issue to come to sustainable development and to reduce carbon dioxide emissions. Particularly after the first oil crisis, many innovative techniques have been introduced to lower the energy consumption or to use renewable energy sources, but not all techniques have been broadly adopted. The differences between these innovative techniques are large. An energy saving technique can be relatively simple or rather complex and in some cases it can directly replace the conventional product or large adjustments in the building design must be made.

Energy saving techniques and the use of renewables can reduce costs and society in general agrees upon the necessity of adopting them. Although high ambitions regarding the energy performance of the forthcoming building are often expressed during the initial phase of a building project, these ambitions are only in a few cases resulting in buildings incorporating many energy saving or renewable techniques. In this paper we intend to make a contribution to the knowledge on decision making processes on adopting energy saving techniques by identifying the relations between stakeholders involved in building processes. The framework is based on decision making theory and innovation adoption theory in order to generate insights in the influences of the organisational environment, in which different types of building processes take place. The central question is:

How can the adoption process of innovative techniques that lower the energy consumption or use renewable energy sources in the building industry be positively influenced?

It is expected that the organisations or persons involved in the building process are of influence on the adoption process, whereby the ambitions stated by the principal before construction and the actual energy performance after construction often do not correspond with each other. In a building process some organisations or persons are only for a limited timepath involved and all have different interests and targets. Therefore, many reasons to install or to reject energy techniques can exist, but they do not always coincide.

Firstly, the theoretical framework will be formulated in which the innovation adoption theory of Rogers (2003), Dieperink et al. (2004), and Hartmann et al. (2008) play an important role. Secondly, the research framework will be explained. Thirdly, the basic characteristics of the main types of building projects will be addressed. The research methodology is described in section five and, finally, in section six the first empirical results are discussed.

2. Theoretical framework

Rogers (2003, pp. 12) states that: *an innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption*. In this paper the *idea, practice, or object* are techniques that lower the energy consumption or techniques that make it possible to fulfil the need for energy in a renewable way. The *individual or other unit of adoption* will be looked for within building projects and will in this paper be called actors. The diffusion (*the process in which an innovation is communicated through certain channels over time among the members of a social system,* Rogers, 2003, pp. 5) and rate of adoption (*the relative speed with which an innovation is adopted by members of a social system*, ibid, pp. 23) can differ strongly per technique. *The rate of adoption is the relative speed with which an innovation is adopted by members of a social system* (ibid., pp. 221). Five variables are distinguished which determine this rate of adoption. The first variable, perceived attributes of innovations, brings five attributes together, which are:

1. Relative advantage: the degree to which an innovation is perceived as being better than the idea it supersedes. The relative advantage of an innovation, as perceived by the members of a social system, is positively related to its rate of adoption (ibid., pp. 229, 233);
2. Compatibility: the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters. The compatibility of an innovation, as perceived by members of a social system, is positively related to its rate of adoption (ibid., pp. 240, 249);
3. Complexity: the degree to which an innovation is perceived as relatively difficult to understand and use. The complexity of an innovation, as perceived by members of a social system, is negatively related to its rate of adoption (ibid., pp. 257);
4. Trialability: the degree to which an innovation may be experimented with on a limited basis. The trialability of an innovation, as perceived by members of a social system, is positively related to its rate of adoption (ibid., pp. 258).
5. Observability: the degree to which the results of an innovation are visible to others. The observability of an innovation, as perceived by members of a social system, is positively related to its rate of adoption (ibid., pp. 258).

The five attributes all join the same aspect “as perceived by members of a social system”. A social system is defined by Rogers as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. The members or units of a social system may be individuals, informal groups, organizations, and/or subsystems (ibid., pp. 23). In this research the social system consists of stakeholders of building processes. Therefore, a stakeholder is in this case a person with an interest or concern in a building project. Not all stakeholders can exert influence on the progress and outcomes of a building project. The particular group of stakeholders that can exert influence is called actors. This research will focus on them.

These actors or the organizations they operate in are influenced not only by the characteristics of the innovative technique itself, like expressed by the five attributes of Rogers, but are also influenced by the context in which the decision making process has to be taken. Dieperink et al. (2004) stresses the importance of studying adoption in its context. The framework of these authors links companies’ characteristics and the decision making process & assessments on the one hand with macro developments, technical aspects, economic aspects and the company’s context on the other hand. Especially in building projects, where organisational connections exist adjacent to inter-organisational connections, decisions are taken in a complex context. Insights in these structures can contribute to decision making theory.

Vermeulen et al. (2006) have translated the framework of Dieperink et al. (2004) to specify first and second level variables, which explain the adoption of energy innovations for new office buildings. They mention that the actor’s characteristics and the networks in which the actor participates have impact on the decision making process and therefore on the rate of adoption. But in their research only the adoption in commercial real estate has been addressed and not the adoption in residential real estate. In residential real estate installations account for a much smaller part of the building costs. This offers interesting opportunities for further research, because the energy consumption is in residential real estate as high as in commercial real estate (PEGO et al., 2007).

Besides the fact that variables and attributes are defined that can accelerate the adoption process, there also exists a perspective in which barriers are defined that decelerate or block adoption processes. By debating on these barriers these scholars (e.g. De Man, 1983; Painuly, 2001) also address the need to include variables that can explain the influence of the context in which innovations are introduced to the potential adopter. Painuly (2001) states on barriers to renewable energy penetration for example that *there are different barriers that need to be overcome…through various actions by stakeholders and governmental policy measures* (ibid, pp. 77). Research of DeCanio (1998) also showed that *data on the profitability of lighting upgrades…strongly support the conclusion that organizational and institutional factors are important determinants of firms’ investment behaviour and outcomes* (ibid, pp. 453). Furthermore, it is stated that profitable investments to save energy are possibly not implemented, because of internal barriers in private and public organizations. To be able to understand adoption of energy saving techniques the specific context has to be taken into account. Regarding public organizations Hartmann et al. (2008) offer a model of the

adoption process that links the public dimension and professional dimension of the client with the innovation perception (see Figure 1). However, the fact that different levels of public involvement are present (for example because of building regulations on energy performance) has, as far as we know, not been included in existing innovation adoption theories. In general public involvement takes place on two different levels:

- Micro: Individual building projects where the government is involved by means of regulation and inspection. In some situations local governments can be more actively involved or even be the principal or user;
- Macro: Many decisions to stimulate the adoption of techniques that reduce the energy consumption are taken on a national level or supra-national level.

This research distinguishes four different clients and two sorts of buildings to come to a meso scale:

1. Residential real estate developed by social housing corporations;
2. Residential real estate developed by private ownership;
3. Commercial real estate developed by investors;
4. Commercial real estate developed by the government.

Every type of building process needs to be analysed regarding decision-maker, underlying motivations and moment of decision-making in adopting or rejecting energy saving techniques in a project specific context.

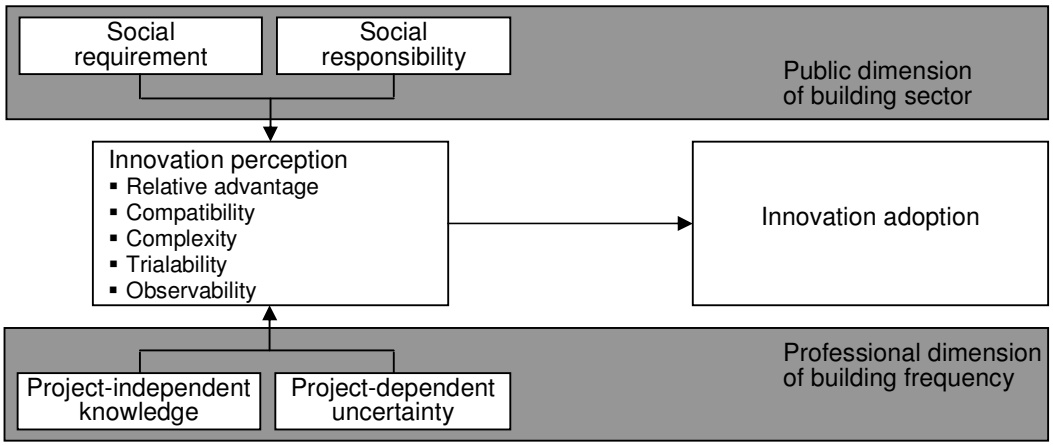

Figure 1: Influences on the innovation adoption of professional public clients (Hartmann, et al., 2008)

3. Research framework

In analyzing the four building projects three research questions reflecting on the deciding actor, underlying motivations and timepath of involvement are formulated:

1. Which actors decide on the adoption and application of energy saving techniques?
2. Which arguments and motivations are underlying their decisions?
3. When and how are adoption decisions taken in the design and construction process?

3.1 Allocating decisions to actors

In the construction industry the social system consists of a great variety of stakeholders related by one or more specific building processes. As mentioned before, a stakeholder is in general a person or organization with an interest or concern in a building project. In a research on the perceptions of stakeholders on alternative energy technologies in buildings, Cooke et al. (2007) distinguish eight different stakeholders: architects, building service engineers, clients, specialist consultants, planners, project managers or quantity surveyors, technology suppliers and contractors. Based on forty-one interviews Cooke et al. (2007) drew up the perceptions of stakeholders on alternative energy technologies. These stakeholders could be so called potential adopters. Vermeulen et al. (2006, pp. 2720) explain what potential adopters are: *…by 'potential adopters' we mean those persons in a decision making position in a project development organization who decide what technological innovations to incorporate in the construction of a new office building.* In this research this select group of stakeholders is called actors.

Besides the term stakeholders another term, "building professionals", is often deployed. Lo et al. (2006) use it for addressing practicing construction engineers, civil engineers, and architects, who are qualified and have at least three years of working experience. However, within the development of residential real estate by private ownership the client can not be expected to be qualified or to have at least three years of

experience, therefore in this research the term building professionals is probably not appropriate for all stakeholders or respondents, especially those involved in developing privately owned residential real estate.

Furthermore, it is necessary to be aware of the differences between the communication process and the actual decision process. Rogers clearly addresses the communication process as a preliminary phase. Lo et al. (2006) speak of the influence of building professionals in the decision-making process without giving more insights in which consultation took place before adoption or who exactly took the decision. In this paper the term actor will be used to refer to the specific group of stakeholders that can directly influence the building project and its result. In this research nine different actors are distinguished, which are described in Table 1. It could be that two actors in one project do not have direct communication, but that one of the two still strongly is influenced by the estimated needs of the other. For example an architect will probably give thought to how a building is going to be used.

Table 1: Descriptions of the nine actors regarded in this research

	Actor	Description
Granters	Client – Principal (Cl)	Person or organisation requesting the constructive service of a professional person or organisation
	Customer- User (Cu)	Person or organisation making use of the provided building
	Warden (W)	Person or organisation responsible for the supervision of and maintenance on the building and its location
	Property developer (PD)	Person or organisation that converts land to a new purpose, especially by constructing buildings
	Municipality (Mu)	A town or district having a local government that enforces building regulations
Takers	Architect (A)	Person who designs buildings and in most cases supervises their construction
	Consultant (Cs)	Person who or organisation that provides expert advice professionally
	Contractor (Co)	Person who or organisation that undertakes a contract to provide materials and/or labour for a construction project
	Subcontractor (Sc)	Firm or person that carries out work for a company as part of a larger project
	Manufacturer (Ma)	Firm that fabricates construction components and/or materials

3.2 Arguments and motivations

The reasons to adopt or reject certain energy saving techniques can have a broad background. Past research addresses the use of multicriteria decision-making frameworks (e.g. Haralambopoulos et al., 2003; Banaitiene et al., 2006) and the role of decision support systems (e.g. Hersch, 1999) to chose for the adoption of a specific technique out of a range of alternatives. However, in that case the actors of the building project should already be familiar with all existing alternatives.

Rogers' attribute "relative advantage" often gets more attention than the other attributes when in the social system known energy saving techniques are compared. The final choice for an energy saving technique can then be based on variables like fuel saved, return on investment, number of created jobs, environmental contribution and involved risks (Haralambopoulos et al., 2003). In this research attention will be paid to the preliminary phase of becoming familiar with the existence of energy saving techniques by addressing the five mentioned attributes of Rogers that influence the rate of adoption and by setting an environmental context in line with the model of Hartmann et al. (2008).

3.3 Design and construction processes

This paragraph addresses the different phases of the design and construction process, because *it should … be recognized that any given decision is likely to be part of a series of decisions or decision processes rather than occurring in isolation* (Hersh, 1999, pp. 397). In other words preceding and following phases can be of influence on the phase in which decisions are made. By using a scheme of the phases in a standard building process it will be possible to get more insights in when the decisions are taken. Process schemes of Arditi & Gunaydin (1997) and Turin (2003) link actors and phases of the building project directly, but by insinuating these relations in advance, different process schemes need to be prepared reflecting on different project organisation forms. Therefore a process scheme will be used of the University of Salford (Kagioglou et al., 1998), that does not mention any actors or stakeholders yet.

Decisions on the adoption of complex energy saving techniques can be taken in early phases of the building process to minimize efforts and costs of installation. It is expected that the early phases in construction projects are in general most suitable to address rigorous energetic requirements, because…*the early phase of a project development is the most important time for innovative activities and for planning a project execution that will optimise project value generation* (Kolltveit et al, 2004, pp. 545).

4. Characteristics decision making processes in building projects

We are aware that the list with the four types of building projects, mentioned in section 2, is not complete regarding construction types and possible ways to come to project development. We use this distinction because of the different levels of expertise, accountability of the principals, and the specific energy consumption patterns of the regarded objects. In this section some characteristics of these kinds of real estate and the actors involved in the building processes will be mentioned regarding the Dutch situation.

4.1 Residential real estate developed by social housing corporations

Social housing corporations own more than one third of the Dutch houses. By the end of 2003 the total number of houses owned by corporations was 2,420,500 (Dekker, 2004). The objective of these corporations is to provide affordable housing of a proper quality even for households with a minimum income. It is hard to achieve this objective in a market with relatively high land prices of € 341.- /m^2 on average. Besides, the average building costs of a rented house are € 86,000.- (excluding VAT) (Bouwend Nederland, 2007) and the adoption of energy saving techniques makes even higher investments necessary.

A subsidy on the rent is provided for the tenants of this type of residential real estate, when their income minus the cost of renting are below certain thresholds. These thresholds are solely based on the basic costs of hiring without service costs or energy costs. On average the basic costs are € 402.- per month (Bouwend Nederland, 2007). This means that extra investments that go beyond the basic regulations of the Building Code[1], can not be earned back by raising the monthly rent, because an increase will result in a subsidy stop for the tenant. However, the tenant does receive a lower energy bill and therefore will benefit from the investment done by the housing corporation.

De Man (1983) specified certain barriers that obstruct the adoption of energy saving techniques in the social housing sector. He distinguished structural, regulatory, and interpretive barriers. These barriers only addressed misfits in the relation between the national government and the social housing sector, but the organisation of the building process itself was not addressed. Nowadays social housing corporations are considered to be highly experienced principals or property developers regarding real estate, but based on the investments costs less experience is expected to exist on the adoption of innovative techniques.

4.2 Residential real estate developed by private ownership

In recent years the Dutch government stimulated the development of residential real estate by private ownership. This type of development is considered to be favourable because of the higher level of differentiation in building designs and of customer satisfaction. In most cases these houses are detached and are middle to high-priced. Regarding the adoption of energy saving techniques the financial aspect could form a smaller barrier compared to the development of social housing, but the principal's acquaintance with existing energy saving techniques is expected to be a bigger barrier.

In developing residential real estate by private ownership the role of the principal is only in some cases ascribed to environmentalists that wish to adopt several energy saving techniques. However, in most cases the Building Code will be used to specify the quality level and just some basic energy saving techniques are applied. When the principal is not familiar with the broad range of energy saving techniques that is available nowadays, an important role can be played by the other actors that are involved in the project. Some architects for example are specialists in sustainable building and have progressive designs of houses available. In other cases it is the municipality that stimulates the adoption of energy saving techniques by offering information, subsidies or certificates. In these projects macro, meso and micro scale considerations can have an interesting overlap.

4.3 Commercial real estate developed by investors

The development of commercial real estate can take place on demand of a company that is in need of work space to provide service to its customers. However, in this research the development of real estate by (institutional) investors will be regarded, because in this design and building process the principal and user are not one and the same actor.

In the Netherlands the total number of offices is approximately 60.000 (Prendergast et al., 2006) with a value of 250 billion Euro (DTZ Zadelhoff, 2007). Although commercial real estate uses large quantities of energy, the building regulation on the energy consumption of commercial real estate is not as hard to comply with as the regulation for residential real estate. An obstacle in adopting energy saving techniques forms the fact that in many projects the future user of the building is not known yet. Therefore, the investor does not know what the energy consumption of user pattern will be, and if the future user is willingly to pay for the extra energy saving techniques in exchange for lower energy bills.

[1] The Dutch Building Code specifies the minimum quality of new buildings, among the prescripts is an Energy Performance Coefficient that specifies a maximum energy consumption per object.

4.4 Commercial real estate developed by the government

In many countries governments play an important role in developing commercial real estate. In the Netherlands the national government alone owns offices with a gross surface of 3,2 million m^2 (Min. VROM, 2007). By being principal and (dedicated) user at the same time a government (department) should be able to benefit from the investments during their whole lifespan. Furthermore, it is assumed that governmental principals set an example for the building industry by adopting state of the art energy saving techniques or by adopting energy saving techniques that are not profitable yet, but are considered to be sustainable. The government could be an experienced client (like Hartmann et al. (2008) already mentioned) with a strong social responsibility.

5. Methodology for future research

The research will be conducted by using structured questionnaires. The respondents will be chosen in such a way that they can reflect on one or more of the four building processes specified. Seven preliminary interviews among a social housing corporation, municipality, province, architect agency, and project developer demonstrated the need for a structured questionnaire, but with the possibility to include personal reflections on the questions and on the answer options. A scheme (see Figure 2) reflecting on the roles of the actors within the decision making process will be used to structure the answers regarding the first and third research question. The second research question on arguments and motivations is expected to result in figures comparable to Figure 1 of Hartman et al. (2008).

Furthermore, the first few interviews already demonstrated the relevance of financial aspects of energy saving and the necessity to operate demand based. This means that the client or user needs be willing to pay for the techniques. Without this willingness the Building Code and local regulations form the basics to achieve a certain energy performance.

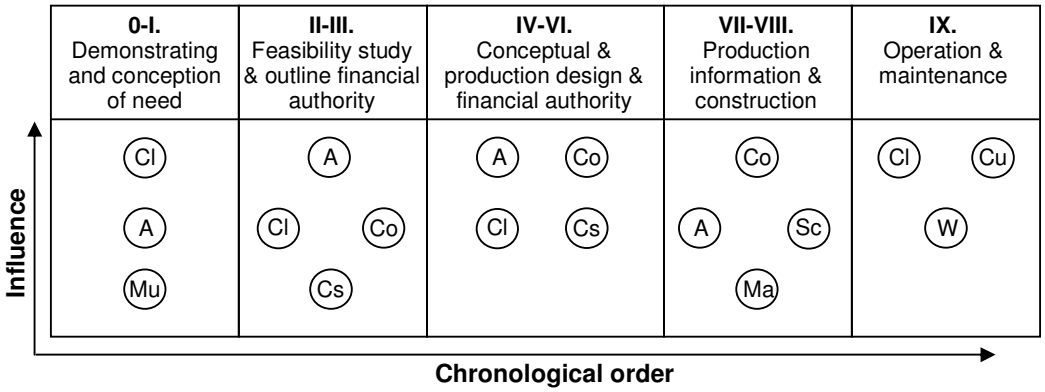

Figure 2 Possible representations of empirical data resulting from research on decision making actors in different phases of a building process.

6. First empirical results

Two preliminary projects had taken place to get insights in the adoption of energy saving and renewable energy techniques in the four building processes. The first project consisted of a research among social housing corporations regarding the decision to adopt or reject passive house designs. This research was conducted to reflect on the first phases (0-III) of buildings projects of the first category “residential real estate developed by social housing corporations” The second project focused on the possibilities to reduce Life Cycle Costs (LCC) by using Service Level Agreements (SLA) in commercial real estate. The LCC and SLA included among others heating systems and energy costs. This project considered commercial real estate in the existing building stock (phase IX) developed by investors.

6.1 Adoption of the passive house concept by social housing corporations

By using the integrative framework of Dieperink et al. (2004) research was conducted on which factors are of influence on the decision making process on adopting passiv houses by social housing corporations. In general the main categories that influence these processes were: government, market & society, company’s characteristics, economic aspects, technical aspects, and macro developments. A methodology of reviewed surveying was used in which surveys were preceding extensive interviews among ten respondents of different housing corporations in the eastern part of The Netherlands.

Although these corporations have a strong social responsibility within the Dutch community, the surveys made clear that the economic aspects were considered to be the most important drivers to implement energy saving techniques (Dekker, 2008). The respondents could define, within the main categories, which aspects surrounding a project are influencing the decision making process most strongly. The results are given in Table 2. Furthermore, the results of the interviews showed that the corporations are well-disposed

towards innovations that can reduce the energy consumption. One of the reasons for this sympathy is the rising energy price that increases living costs of their tenants.

Table 2: Relevance of aspects within main categories that influence the decision making process on adopting passiv houses according to respondents (Dekker, 2008).

Government	Market & society	Economic aspects	Technical aspects	Macro developments
1. Policy & regulations	1. Demand	1. Investment costs	1. Reliability	1. Energy prices
2. Incentive programs	2. Vertical collaboration	2. Pay back period	2. User-friendliness	2. Environmental considerations
3. Subsidies & credits	3. Influence of suppliers	3. Efficiency	3. Complexity	3. State of economy
4. Support	4. Rate of R&D		4. Technical practicability	4. Developments involving energy supply
5. Knowledge transfer	5. Union		5. Alternative options	
6. Convenants			6. Organisational practicability	
			7. Problems at startup	

6.2 Importance of life cycle costs and service level agreements among investors

In the research of Lenters (2008) the acquaintance with LCC and SLA among Dutch and German commercial companies and their vision on the possibilities to reduce costs by using SLA were revealed. Six Dutch and six German respondents have been interviewed. The interviews were again preceded by surveys.

Two out of twelve respondents were unacquainted with LCC. Five of the respondents indicated to be able to compute LCC themselves. Six persons mentioned that they were already familiar with the concept for more than five years. Regarding the energy consumption of commercial real estate SLA are used in the field of maintenance of building installations, climate control systems, heating systems, and electric equipment. In these situations the respondents state that these services are in most situations provided to the owner of the real estate object and not to the user. Services involving the maintenance of building installations and climate control systems are more often incorporated in SLA than services involving heating systems and electric equipment. These results are relevant to gain insights on how actors involved during design & construction phases of the building process and actors involved during operation & maintenance can match there interests.

7. Conclusions

This research aims at improving the understanding on how actors are involved in the processes of adopting and applying energy saving techniques. Interviews and structured questionnaires among social housing corporations shows that the bottom line for the energy performance of buildings given by the national Building Code or in some cases given by additional regulations provided by the municipality, and not surpassed willingly because of the involved investment costs. However, these regulations make sure that the corporations are requesting for energy saving techniques in an early stage of the building project. Furthermore, it seems at this moment that these regulations are their strongest motivation in applying energy saving techniques.

The foreseen methodology of structured questionnaires will give direct insights on micro scale. Insights on meso scale, reflected by the four distinguished building processes, can be generated by using a) a process protocol that specifies actor involvement in combination with b) a higher number of respondents than in former research was done. In the end we expect to be able to provide multi-actors strategies to enhance the adoption of energy saving techniques.

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References

Arditi, D. and H.M. Gunaydin 1997, Total quality management in the construction process, *International Journal of Project Management*, vol. 15, no. 4, pp. 235-243.

Banaitiene, N., A. Banaitis, A. Kaklauskas and E.K. Zavadskas 2008, Evaluating the life cycle of a building: A multivariant and multiple criteria approach, *Omega*, 36, pp. 429-441.

Bouwend Nederland, 2007, De bouw in cijfers 2002-2006; uitgave 2007 (In Dutch).

Cooke, R., A. Cripps, A. Irwin and M. Kolokotroni 2007, Alternative energy technologies in buildings: Stakeholder perceptions, *Renewable Energy*, 32, pp. 2320-2333.

DeCanio, S.J. 1998, The efficiency paradox: bureaucratic and organizational barriers to profitable energy-saving investments, *Energy Policy*, vol. 26, no. 5, pp. 441-454.

Dekker, J.P.M. 2008, Passiefhuis in actie; een onderzoek naar het besluitvormingsproces bij de adoptie van passiefhuizen door woningcorporaties, BAM Woningbouw Deventer, master thesis, Twente University, CME.

Dekker, S.M. 2004, Prestaties van woningcorporaties in 2003, prestatieafspraken en toezicht in 2004 (In Dutch), Ministry of Housing, Spatial Planning and the Environment (VROM), DGW/SR2004130681.

De Man, R. 1983, Barriers to energy conservation – the case of the Netherlands social housing sector, *Energy Policy*, December 1983, pp. 363-368.

Dieperink, C., I. Brand and W. Vermeulen 2004, Diffusion of energy-saving innovations in industry and the built environment: Dutch studies as inputs for a more integrated analytical framework, *Energy Policy*, 32, 6, pp. 773-784.

DTZ Zadelhoff 2007, Investments without limits; The Dutch investment market for commercial property, June 2007.

European Council (EC) 2002, Energy Performance Building Directive (EPBD), Directive 2002/91/EC of the European Parliament and Council of 16 December 2002 on the energy performance of buildings.

Haralambopoulos, D.A. and H. Polatidis 2003, Renewable energy projects: structuring a multi-criteria group decision-making framework, *Renewable Energy,* 28, pp. 961-973.

Hartmann, A., I.M.M.J. Reymen and G. van Oosterom 2008, Factors constituting the innovation adoption environment of professional public clients (forthcoming), *Building Research & Information*.

Hersh, M.A. 1999, Sustainable Decision Making: The Role of Decision Support Systems, IEEE Transactions on Systems, Man, and Cybernetics – Part C, *Applications and Reviews*, vol. 29, no. 3, pp. 395-408.

Kagioglou, M., R. Cooper, G. Aouad, J. Hinks, M. Sexton and D. Sheath 1998, Process protocol, final report, ISBN 090-289-619-9, University of Salford.

Kolltveit, B.J. and K. Grønhaug 2004, The importance of the early phase: the case of construction and building projects, *International Journal of Project Management*, 22, pp. 545-551.

Lenters, Y. 2008, The reduction of life cycle costs by the application of service level agreements, master thesis, Twente University, CE&M.

Lo, S.M., C.M. Zhao and W.Y. Cheng 2006, Perceptions of building professionals on sustainable development: A comparative study between Hong Kong and Shenyang, *Energy and Buildings*, 38, pp. 1327-1334.

Ministry of Housing, Spatial Planning and the Environment (Min. VROM) 2007, Rijksgebouwendienst; Jaarverslag 2007 (In Dutch), no. 7295.

Painuly, J.P. 2001, Barriers to renewable energy penetration; a framework for analysis, *Renewable Energy*, 24, pp. 73-89.

PeGO, EnergieNed and Aedes 2007, Meer met Minder; Nationaal energiebesparingplan van energieleveranciers en organisaties actief in de gebouwde omgeving (in Dutch), June 2007.

Prendergast, E. and Y. Maréchal 2006, Aantal utiliteitsgebouwen in Nederland; Methodiek en resultaten voor 2005 (In Dutch), Mobius consult, in order of the Netherlands Ministry of Housing, Spatial Planning and the Environment (VROM).

Rogers, E.M. 2003, Diffusion of innovations, fifth edition, ISBN 0-7432-2209-1.

Turin, D.A. 2003, Building as a process, *Building Research & Information*, 31, 2, pp. 180-187.

Vermeulen, W.J.V. and J. Hovens 2006, Competing explanations for adopting energy innovations for new office buildings, *Energy Policy*, 34, 17, pp. 2719-2735.