THE ENERGY PERFORMANCE OF OFFICE BUILDINGS THROUGHOUT THEIR BUILDING PROCESS

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Abstract

Many innovative techniques and policy measures have been introduced to reduce energy consumption. Despite the high ambitions and societal pressures, the adoption rate of energy measures in office buildings is still low. Using adoption theories this paper provides a framework to analyse the adoption process of energy saving techniques in building processes. This framework is used to analyse the design and building processes of four Dutch office buildings. In these processes the roles of the stakeholders, in relation to the adoption of energy measures, are identified during every phase of the building projects. It enables us to better understand by which means certain stakeholders can exert influence on adopting or rejecting certain energy concepts and measures. The complex network of temporary relationships among stakeholders makes it hard to turn high ambitions into a broad adoption of multiple energy techniques, which can lower the energy use or which make use of renewable sources.

Keywords: stakeholder, decision making, energy measures, office

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 has an important impact on the reduction of carbon dioxide emissions and sustainability in general. Many innovative techniques have been introduced to lower the energy consumption or to use renewable energy sources, but the adoption of techniques is hampered by multiple barriers.

Innovative sustainable techniques differ in terms of complexity and costs. In some cases new techniques can directly replace the conventional product, in other cases large adjustments in a building have to be made. Energy saving techniques can reduce life-cycle costs, but often lead to higher investment costs. Although many measures are widely accepted in society and high ambitions regarding the energy performance of forthcoming buildings are often expressed during the initial phase of a building project, these ambitions are not always realised in practice. We expect that this can be related to the influence of specific stakeholders in the design and construction process of buildings. Policy measures focusing on the environmental impact (or more specific energy use) of buildings might not have the expected impact, if there is a lack of social acceptation of those measures (see e.g. Raven 2006). Therefore sustainable energy measures will not be successfully implemented as long as we do not have a clear understanding of the behavior of the main stakeholders in the construction process, e.g. architects, developers, builders, clients and end-users.

It is expected that the stakeholders involved in the building process are of influence on the adoption process (Cooke et al, 2007), whereby the ambitions stated by the clients before construction and the achieved energy performance after construction often do not correspond with each other, due to reduced budgets or the need for less investments costs during the

design process or architectural, constructional and installation failures during the construction process. In the whole building process some organisations or persons are only for a limited time path involved and all have different interests and targets. Therefore, many individual reasons to adopt or to reject energy techniques will exist.
Our objective is to make a contribution to the knowledge on decision making processes by developing a framework to analyse the influence of stakeholders on the adoption of energy saving techniques. Our framework is based on innovation adoption theories. We focused on the stakeholders who are involved in the adoption process of innovative techniques that lower the energy consumption or make use of renewable energy sources. The case studies are design and building processes of Dutch office buildings.

FRAMEWORK TO ANALYSE ADOPTION IN BUILDING PROCESSES

This section addresses the innovation adoption theory as presented by Rogers (2003). Afterwards innovation adoption processes will be placed in the context of the built environment. Finally, this section presents a framework to analyse building processes.

Adoption theory

Many studies have been published on adoption of innovations. Well-known is the work of Rogers that gives insights in which characteristics of energy saving techniques are relevant, how the adoption process can be phased, and which kind of adopters exist. His work is being used to come to a framework on the adoption process of energy saving techniques in the built environment.
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* in building projects are a variety of stakeholders. A stakeholder is in our case an individual or organisation 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 group of stakeholders that can exert influence is further referred to in this paper as 'actors'.
Rogers (2003) defines five attributes that strongly influence the rate of adoption of innovations, namely relative advantage, compatibility, complexity, trialability and observability. This means for example that a high level of complexity will more likely result in a lower adoption of an innovative energy saving techniques than a low level of complexity.
In the process of adopting or rejecting an innovation five phases are distinguished, namely (ibid., pp. 171-189):

1. Knowledge: in this stage an individual (in our case actor) is exposed to an innovation's existence and gains an understanding of how it functions;
2. Persuasion: the individual forms a favourable or unfavourable attitude toward the innovation. The mentioned perceived attributes are important in this stage;
3. Decision: activities are undertaken that lead to a choice to adopt or reject an innovation;
4. Implementation: this occurs when an individual puts an innovation to use;
5. Confirmation: in this stage the individual seeks to avoid a state of dissonance or to reduce it if it occurs.

Adoption processes in the building context

Dieperink et al. (2004) and Hartmann et al. (2008) stress the importance of studying adoption in its context. The specific characteristics of the context have to be understood in order to

analyse the decision-making process of innovations. Dieperink et al. (2004) for instance expands Roger's model by linking the adoption process with macro developments, technical aspects, economic aspects and the company's context.
The integrative model of Dieperink et al. (2004) explaining the diffusion of innovations offers a detailed structure to align motivations and arguments of actors for adopting or rejecting energy saving techniques. Vermeulen et al. (2006) elaborates on the model of Dieperink et al. (2004) by specifying 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 adoption rate. This network forms the heart of our framework.
Research of Hartmann et al. (2008) focuses on the adoption of innovations by professional public clients, in which four conflicting factors were strongly affecting the innovation perception of this actor. They offer a model of the adoption process that links the public dimension and professional dimension of the client with the innovation perception. These scholars see *risk* as an important additional innovation attribute. Risk by uncertainties can be reduced among others by bringing actors together in an early stage, by referring to similar solutions, and by cooperative behaviour.
Based on these studies we distinguish four contextual dimensions, namely: the characteristics of the actors in their segment of the construction industry, the context of the project, the macro developments, and the state of technology. The state of technology is based on Dieperink's "technical aspects" and Hartmann's attribute "risk". By specifying which techniques are in which stage of the innovation life cycle, risks can partially be assessed. Energy measures that have proven themselves are considered to be less risky than non-proven measures.

Framework to analyse building projects

Building projects can be characterised as inter-organisational projects. In building projects, where organisational connections exist adjacent to inter-organisational connections, decisions are taken in a complex context. In every phase of the building process actors and stakeholders join or leave. Different phases of building processes can be profoundly explained by using the process protocol of the University of Salford as specified in Table 1.

Table 1: *Phases in the design and construction process (Kagioglou, et al., 1998).*

Group	Phases
Pre-project phases	0. Demonstrating the need
	I. Conception of need
	II. Outline feasibility
	III. Substantive feasibility study & outline financial authority
Pre-construction phases	IV. Outline conceptual design
	V. Full conceptual design
	VI. Production design procurement & full financial authority
Construction phases	VII. Production information
	VIII. Construction
Post completion phase	IX. Operation & maintenance

This arrangement shows some similarities compared to the innovation decision process of Rogers. The awareness of a certain necessity and generating an attitude are prevailing in the first phases (phase 1 and 2). In the final drawings and documents, before setting a price for construction, adoption or rejection decisions need to be taken (phase 3). The construction process needs to cope with the installation procedure for the specific energy techniques (phase 4). In the end the user of the building will experience if the techniques perform and really can save energy (phase 5).

In the building process at least ten actors can be considered to have direct influence in the adoption or rejection of energy saving techniques (see Table 2). The actors are involved in different stages of the building process. The trajectory to come from an energy saving concept to specific energy saving techniques, the contextual factors influencing the process, and the roles of the actors are included in our framework, being the horizontal axis (see Figure 1). The five phases of Rogers are expected to be only partially in line with the phases of the general design and construction process. Individual actors are persuaded and are taking decisions on energy saving measures at different stages in the process. In other words, the overall diffusion process consists of various personal adoption cycli which vary per actor. The vertical axis expresses the level of influence a certain actor has on the adoption of the energy concept, energy measure(s) or energy technique(s).

Table 2: *Descriptions of the ten actors regarded in this research*

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

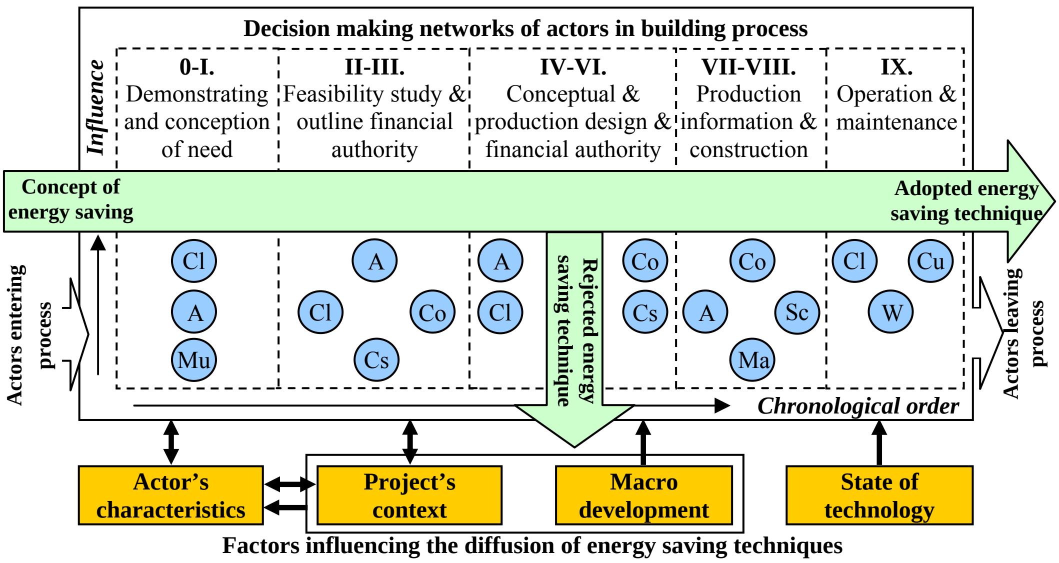

Figure 1*: Framework to analyse the adoption process in building processes.*

CONTEXT OF BUILDING OFFICES

In this section the framework will be operationalized in order to analyse social housing projects by specifying the context in more detail. There are multiple reasons to study the design and construction process of office buildings. Firstly, office buildings use relatively much energy compared to residential buildings. Especially the electric energy use can be significant higher. Secondly, among office buildings large differences exist in building design and in energy use (see Table 3). Thirdly, office buildings often have a relatively short economic and functional life time compared to residential buildings. Therefore, the rate of replacement is relatively high and new innovations or gained experiences can quickly be applied in new project reducing the energy use involved in operating and using this category of buildings. In this section we will further explain the context expressed by the four factors at the bottom of Figure 1.

Table 3: *Energy use of Dutch office buildings (SenterNovem, 2007).*

	Natural gas consumption ($m^3/(m^2 \cdot year)$)			Electric energy use ($kWh/(m^2 \cdot year)$)			N
	20 %	50 %	80 %	20 %	50 %	80 %	
Office buildings 200-500 m^2	6	21	37	35	109	182	44
Office buildings 500-10.000 m^2	6	13	20	32	85	138	37
Office buildings > 10.000 m^2	6	10	14	28	79	82	32
Office buildings insurance comp.	6	15	24	14	129	160	54

Macro development

The developments are clustered in political, juridical and economic events within the construction industry in the Netherlands during the time-period 1998-2010.

Political developments

National and regional governments often try to create conditions that support entrepreneurial activities in order to improve the employment rates in an area. Land plots to construct office buildings or industrial buildings is offered by municipalities for significant lower prices than plots for residential purposes. For companies that operate internationally the Netherlands tries to be as attractive as possible by offering good infrastructure, stable government, public security, well educated population and interesting financial conditions regarding taxes. The costs to run a company in the Netherlands need to be in line with the costs to run a company for example in Germany, Belgium or France in order to keep companies within borders.
Therefore regulations leading to increased investments costs for companies are not favoured. Regulation on the energy performance of office buildings and utility buildings are less ambitious than regulations for residential buildings. Recently, initiatives were undertaken to strongly influence political developments to come to a broad energy transition. By the name of "the Netherlands get new energy" (Anonymous, 2010) and "Energy provision of the Netherlands; today (and tomorrow?)" (Hellinga, 2010) multiple politicians and engineers try to address the urge to make the energy provision more sustainable.

Legal developments

In the time period 1998-2010 the national Building Code of 1992 and 2003 applied for new buildings. Regarding the energy use of office buildings are required: a minimum insulation value of 2.5 $(m^2 \cdot K)/W$, a minimum value for ventilation of 1.0 $dm^3/(s \cdot m^2)$, a maximum value for air infiltration of 0.2 dm^3/s per area with one and the same function and an Energy Performance Coefficient (EPC) of 1.1 at maximum. This EPC expresses a theoretical construction and installation related energy performance of a building under certain standard conditions regarding usage, indoor temperature preferences and outdoor climate. The EPC is namely based on an equation that relates forecasted and permissible building related energy use, incorporating the installed systems for heat production, heat resistance of the building shell and the size of the house, etc. The EPC for office buildings was introduced in 1995, stating a value of 1.9 at maximum. By January 2000 this value was lowered to 1.6. In 2003 a value of 1.5 was issued and in 2008 the current value of 1.1 was introduced. Due to personal preferences, deviant outdoor conditions, and the adoption of non-building related appliances, the actual energy use of a building during usage can strongly differ from the forecasted or hypothetic building related EPC computed during the design phase.

Economic developments

Due to the economic crisis in recent years much office space came available in the last years and few new building projects were initiated. The total service costs of office space increased from \$ 363,- /m^2 in January 2001 to \$ 542,- /m^2 in May 2010. From November 2007 to November 2009 the costs per square meter were higher than in May 2010 (CBS, 2011). According to DTZ Zadelhoff (2011) the annual rent per square meter was € 146,- in 2009; 2.7 % less compared to 2008. In 2009 almost forty million square meter of office space was in use in the Netherlands to accommodate almost 2.3 million so called office jobs. These two values were 1 and 1.4 % respectively lower compared to 2008. A staggering 13.3 % of the total office space was not in use (DTZ, 2011). Besides these relative bad economic conditions, energy prices are increasing.

State of technology

Technical developments are highly important in the field of energy saving techniques and the authors would like to address that for every building project the current state of available energy techniques, which can be regarded by the actors involved. However, actors might attempt to rely on traditional techniques that are known to them by means of former projects. Last decade many new technologies were introduced to save energy. At this moment the high efficiency natural gas boiler, insulation packages with a heat resistance of 2.5 $m^2 \cdot K/W$ and energy saving lighting with presence detectors are common in Dutch offices.

The adoption rates of solar collectors, photovoltaic panels, and heat pumps are still rather low, although the techniques are already available for many years. The expectation is that these adoption rates will improve with the current EPC value of 1.1 or lower. New techniques recently introduced in the construction industry are Phase Change Materials and LED-lighting for example. In the nearby future the availability of techniques is likely to increase, because of growing environmental awareness and higher energy prices. Techniques that are already available will be improved and will probably become cheaper.

Project's context

The context in which offices are designed and constructed, can not easily be described in general terms. Projects with the goal to construct or renovate an office building will bring multiple actors and stakeholders together in different relations. Seldom two projects will bring together the same parties in comparable circumstances and relations. This will also become clear in the following sections.

For offices multiple environmental and energy assessment tools became available worldwide. In the Netherlands GPR Gebouw and GreenCalc$^+$ are for example available to characterize the environmental impact of office buildings. In the European Union the energy performance of new and existing buildings, including offices, can (and in the nearby future needs to) be expressed by a label. The use of assessments and performance indicators can help in communication among the actors and stakeholders. The indicators enable them to directly have a glimpse of the energy performance. In combination with rising energy prices and banks providing financial stimuli for green or energy efficient buildings the aspect of energy receives increasing attention.

Actor's characteristics

Like already stated, multiple actors and stakeholders are brought together, when office buildings need to be constructed or renovated. Different to designing and constructing houses in private ownership, the design and construction process of offices often show different parties regarding the role of financial investor, project developer, principal, user of the building and warden in regards of maintaining the constructed office. Furthermore, multiple organizations are linked these projects to give advice about for example cost management, constructional issues and the mechanical and technical systems. These different organizations all have their own commercial drive to join the project. An office can be constructed from the point of view that it will be rent or that it will be bought by a party that is joining the construction or not. In the last case the object needs to be developed without having one specific user or customer in mind.

RESULTS OF THE CASE STUDY RESEARCH

The cases consider the actors involved in the design, construction and usage of four new office buildings in the Netherlands. Table 4 shows the basic specifications of the studied office buildings. These office buildings were chosen based on their energy performance that goes beyond regulation, the fact that the building processes were finished, enabling us to make an inventory of applied techniques, and the fact that the building processes took place rather recently. Data was collected regarding the different roles of the stakeholders by conducting 22 interviews in total.

Table 4: *Basic specifications of the four case objects being Dutch office building.*

	Case 1	**Case 2**	**Case 3**	**Case 4**
Name office building	Communal Waterworks Amsterdam	De IJsseltoren	QX & QY	De Eempolis
Location	Amsterdam	Zwolle	Best	Amersfoort
Floor area	10.855 m^2	34.000 m^2	14.700 m^2	36.750 m^2
Start design	2000	2003	2003	2000
Start construction	2001	2004	2006	2003
End construction	2003	2005	2007	2004
Energy performance	Q/Q = 0.680 EPC ≈ 1.09	Q/Q = 0.807 EPC ≈ 1.21	EPC_{QX} = 1.44 EPC_{QY} = 1.40	Q/Q = 0.829 EPC ≈ 1.32
Applied energy techniques	$R_{cons,}$= 3.0 m^2K/W U_{glass} = 1.2 W/m^2K Improved air tightness Heat pumps CHS Heat exchanger Enclosed outdoor area Open thermal ceilings T5 lighting	$R_{cons,}$= 3.0 m^2K/W U_{glass} = 1.2 W/m^2K Improved air tightness Heat pump CHS Heat wheel Occupancy sensors	$R_{cons,}$= 1.6-3.0 m^2K/W U_{glass} = 1.2 W/m^2K Improved air tightness Heat pump CHS Heat exchanger Occupancy sensors Ventilated armatures Shading	R_{cons}= 2.0-3.5 m^2K/W U_{glass} = 1.2 W/m^2K Improved air tightness Heat pump Twin coil Ventilated armatures Shading

Case 1: Communal Waterworks Amsterdam (CWA)

The central office of Waternet is located at the west side of Amsterdam. Waternet is the new name for what was before known as Gemeente Waterleidingen Amsterdam (Communal Waterworks Amsterdam; CWA), which was the formal principal and the first user of the

building. The architecture and project leadership were in hands of Van Tilburg & Partners. Seven interviews among the actors in this building process gave insights in the adoption process of the ambitious EPC and the specific energy techniques.
The building has a gross floor area of 10.855 m^2. The construction activities started in 2001 and finished in 2003. The energy performance is stated as an Q/Q of 0.68, which means the EPC is 32% below the by law requested value. This energy performance was achieved by working with the principle of the Trias Energetica. Firstly, the energy demand of the building was reduced by applying among others a highly insulated shell of 3.0 $m^2 \cdot K/W$. Secondly, it was possible for the remaining energy demand to make use of a thermal storage system. Two electric heat pumps provide thermal energy to cool or to heat the building. These heat pumps use green electric energy. Therefore, it seems no carbon dioxide emissions occur by maintaining a comfortable indoor climate in this building.
The owner of the office building was the municipality Amsterdam (expressed as Client (Cl)), that was willing to support the CWA director (expressed as Customer (CU)) in setting an example in sustainability. The ambition was to design an object with a 25% improved energy performance. The technical consultants (DGMR and Techniplan) were asked by the customer and later by the client and architect to specify measures which would reduce the energy consumption.
In principal every measure having a payback period of less than fifteen years was within this project acceptable. The relative advantage of specific energy measures was assessed based on energy analyses, employee's interest, and environmental impact. Photovoltaic panels were mentioned as a technique by the actors that did not fit in the necessary payback period. A green roof was suggested by the architect. Due to limited budgets only that part of the roof that is visible to employees and guests has been covered by sedum instead of the whole roof. Observability was an important issue for still partially applying this specific measure.

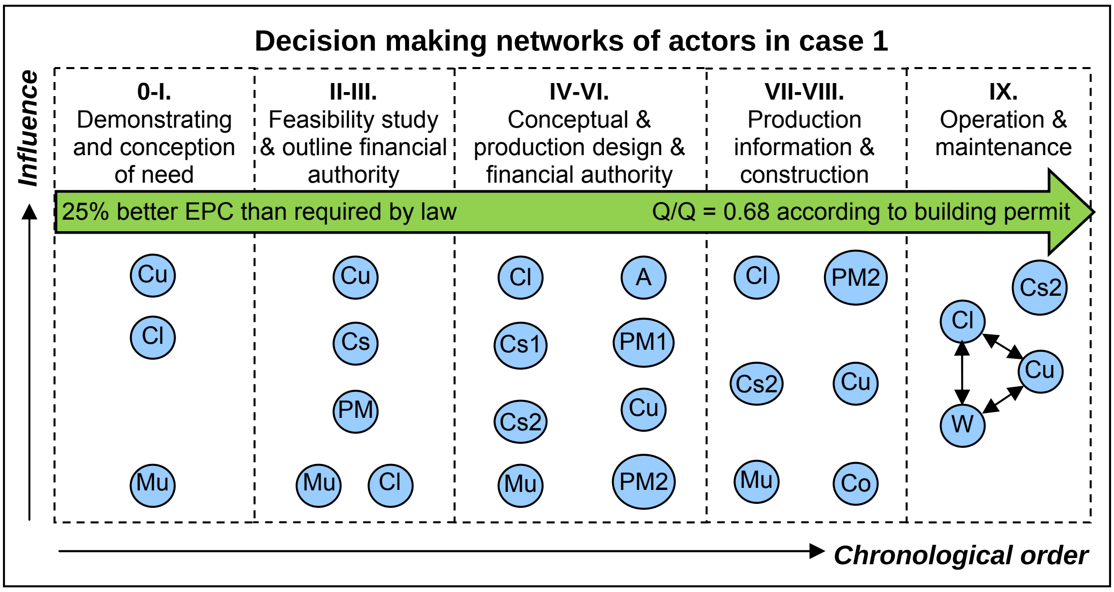

Figure 2: *Stakeholders involved in the design and construction process of Case 1.*

Case 2: De IJsseltoren

In 2004 the building activities started to come to "De IJsseltoren" complex in Zwolle. The complex consists of three constructions and was designed by René Steevensz of PPKS Architects. The development was initiated by MAB Development. The gross floor area of approximately 34,000 m^2 is largely being used by ABN AMRO. The tower, consisting of nineteen floors, reaches up to almost 96 meters. Directly to the east the two lower buildings

of four and six floors are placed on columns. Because of agreements with the national government, which were already initiated in 1996, ABN AMRO committed itself to use timber produced in a sustainable by means of the Forest Stewardship Council (FSC) trademark and to reduce energy consumption.
The buildings encompass for example a proper insulation package, daylight responsive lighting, presence detection for lighting, timed lighting sweep, and automated shut down options for computers. In this case also a thermal storage system and a heat recovery system for air ventilation have been applied. The additional investments to make the building more environmental friendly and to give it a better energy performance were made financially available by ABN AMRO region Zwolle (customer (CU). Bouwfonds computed what the basic costs would be and which additional costs could be expected (project developer (Pd)). The basic costs were paid for by ABN AMRO (client (Cl)). The energy investments needed to have a payback time of seven years or less. In this case the financial relative advantage due to reduced energy costs prevails when comparing multiple techniques. Although a commitment exists to reduce energy use, the compliance with it seems only to be based on the mentioned payback time of seven years or less. In an early stage the idea of a wind mill was abandoned due to foreseen technical complications. Therefore this technique seems to have failed in the means of compatibility in a architectural and juridical context.

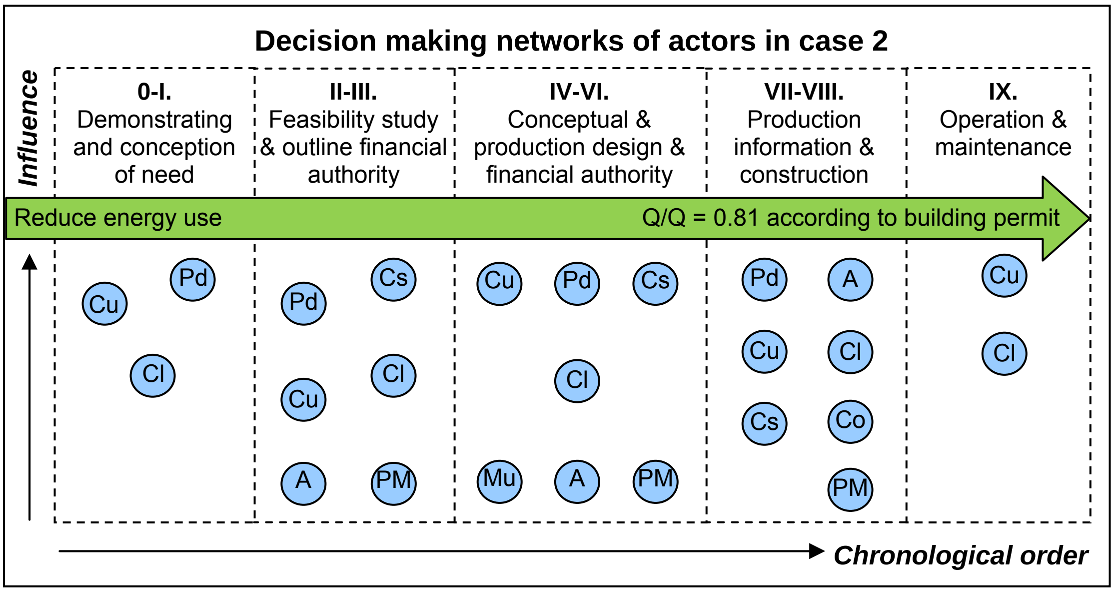

Figure 3: *Stakeholders involved in the design and construction process of Case 2.*

Case 3: QX and QY

In Best two office buildings named “QX” and “QY” offer a combined gross floor space of 14,700 m^2. These offices form the entrance of the Philips Healthcare facilities on that location. Philips Healthcare was also the principal in this project. The architectural firm 01-10 Architecten is responsible for the design. The buildings have three floors and an additional top layer to encompass the installations. EPCs of 1.40 and 1.44 were achieved by applying a well insulated shell with a heat resistance of 3 $m^2 \cdot K/W$. The thermal storage system and a heat recovery system both had a major impact in achieving the good energy performance.
Together with some major industries, Philips has voluntarily committed itself to a governmental agreement to reduce energy use by applying all energy investments with a return on investment period of five years or less. This means that the relative advantage, in the form of cost reductions in energy use, was assessed for different energy techniques. Philips pays for the building (Client (Cl)). During the design and construction process Philips

Healthcare (customer and project developer (Cu)) was allowed to take their own decisions. In this case the insulation, thermal storage system, lightning system and heat resistant glazing were regarded. Observability and trailability were additional attributes in this case. Because Philips is famous for its lighting systems, energy saving lighting systems are by means of observability, more or less, must-haves. The thermal storage system was considered to be a proven system. Although the return on investment period was calculated to be longer than fire years (namely seven years), this techniques was applied.

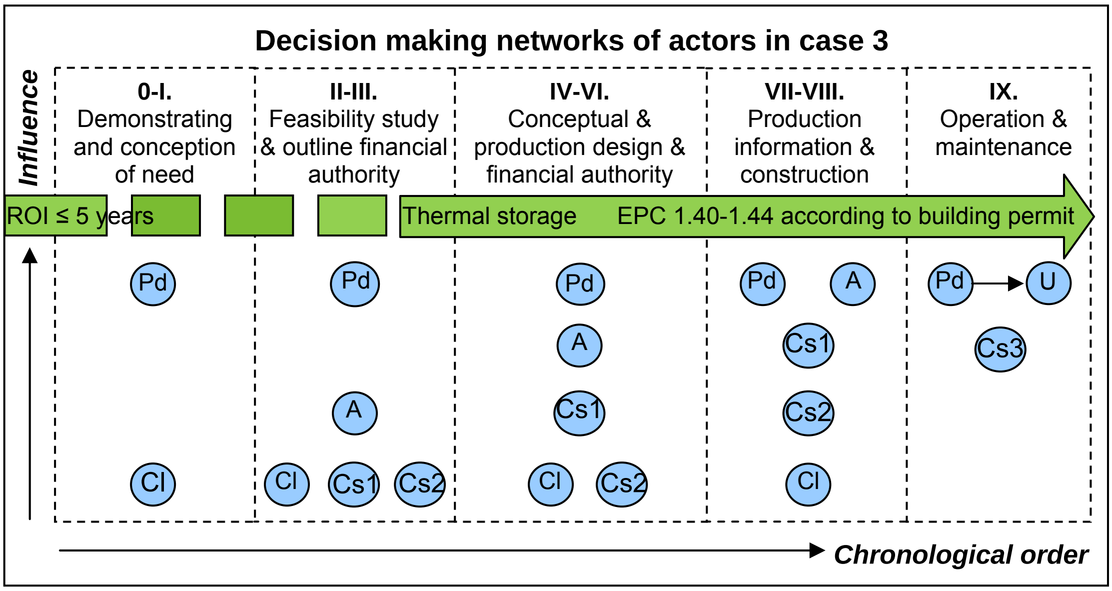

Figure 4: *Stakeholders involved in the design and construction process of Case 3.*

Case 4: De Eempolis

"De Eempolis" forms a long stretched block of office buildings along the northern side of the central railway station in Amersfoort. In this way it functions as a sound barrier. The architect of "De Eempolis" is Jan van Belkum of Arcadis and the principal is NS Poort. The total gross floor space is 36,750 m^2. The total block consists of six sections, which have three to nine floors. At ground level and around the entrance of the station some shops are located. Beneath the ground level parking places for cars and bikes are located.

The construction process started in 2003 and the building activities were finished in 2004. During the design and building process an EPC of 0.55 was mentioned. Nevertheless in the end a less ambitious EPC of ± 1.32 was mentioned in the building permit. The final energy performance was partially achieved by using thermal storage system that uses water of 120 meters below ground level in combination with a low temperature thermal transmission system in the ceilings. These systems are being used for cooling and heating purposes. Unfortunately, it took three years to let these systems operate properly. Furthermore, relatively high thermal insulation values of 3.5 $m^2 \cdot K/W$ and more are applied in the building shell.

The interviews learn that before the building process started, the principal NS Poort (project developer (Pd)) had already stated ambitions regarding the reduction of energy use in their company policy. The company policy is based on the commitment to long-range plans of the national government. These plans aim at twenty percent energy reductions in 2010 compared to the energy use in 1997. These ambitions combined with the wishes of the municipality resulted in a lower Energy Performance Coefficient than necessary to get a building license. Although the investor NS Pension fund did not stimulate energy saving, NS Real Estate being the client (Cl) requested to develop a thermal storage system using heat pumps. At that time the actors did not have any experience with thermal storage systems. The high complexity and low trailability did not seem to be an issue compared to the supposed relative advantage by means of energy use reduction and observability by means of environmental charisma.

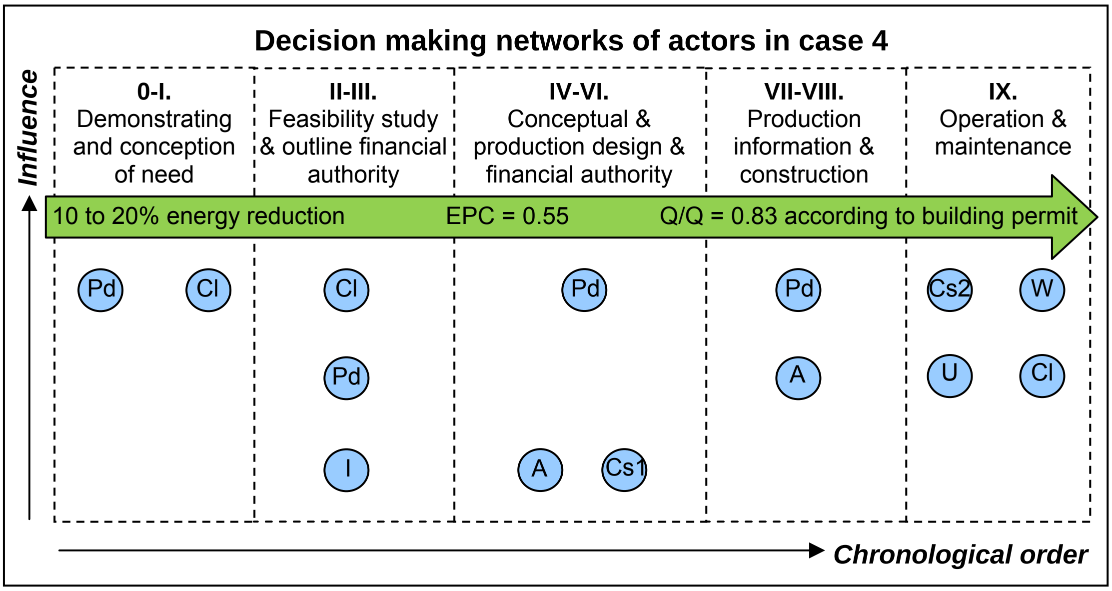

Figure 5: *Stakeholders involved in the design and construction process of Case 4.*

DISCUSSIONS AND CONCLUSIONS

The presented research aims at improving our understanding of adoption processes of energy techniques in building processes. A framework was developed to make the influence of stakeholders visible during different stages of the building process. The framework was applied on four projects. The projects and interviews show that in all cases energy was directly from the start an aspect to consider. In three out of four the need to reduce energy use existed within the organizations, namely Philips, NS Poort, and ABN AMRO. Although one might have expected that a public governmental organization, like the municipality of Amsterdam, would have additional environmental requirements regarding their own facilities in order to set an example, this does not seem to be the case.

Nevertheless, the ambition within the CWA project to reduce the energy use by 25% compared to the energy use required by law, seems to be exceeded by approximately 7%. The ambitions of ABN-AMRO were rather loosely formulated. Within case 4 De Eempolis the ambitions were not that clear either. Large shifts from 10 to 20% and an EPC of 0.55 to a final 17% energy reduction in form of a Q/Q of 0.83 can be seen, although this project had a relatively small number of stakeholders compared to the other cases.

In all cases the project developer had an important role in setting the ambitions. In case 1 CWA the customer filled in the role of project developer in the first fases (0-III) of the project. After that it became apparent that the techniques were adopted and could be implemented, the customer placed himself at the background. Only in the case of CWA the architect was able to influence the energy performance of the design in creative way. In the other projects technical advisors prepared the energy measures in such a way that the architect only needed to insert it in the design. After that, during construction, the architect functioned more or less as a project manager.

The influence of the customer became in case 2, De IJsseltoren, especially apparent when the additional investment costs were not paid for by the client. The fact that the customer was the future user of the building and not the client made it possible to finance the investment based

on the prognosis that future energy use and costs will be lower. In case 4 a higher rent was expected, when the client was able to offer the future users of the object, being the customers, a more energy efficient building.
When we take a close look at Rogers' attributes, multiple attributes are addressed when the actors address the features of adopted and rejected energy techniques in the interviews. Although in most interviews relative advantage in the form of cost and/or energy reductions is mentioned, it is striking to see that almost all considered techniques can be regarded as proven technologies. This can indicate that compatibility with past experiences or trailability (as a degree to which the innovation might be experimented with) are not attributes, but in these cases are conditions to be met first.
Finally, the case studies reveal the relevance of the availability of an energy performance indicator like the Dutch EPC. Although in these projects consultants were asked to look for and investigate possible measures and to calculate the financial and energetic impact of these measures, the ambitions and final marketing of the achieved performance are often based on the EPC and accompanying Q/Q ratio. However, it is not necessarily proven that a low EPC or Q/Q ratio will actually result in lower energy use or lower energy costs. In the case of QX and QY, where the ambition was based on a return on investment within five years instead of a target focusing on energy performance or use, relatively little advancement was made compared to the energy performance in force at that time.
When the energy use of buildings needs to be reduced by an increasing adoption of energy measures, it seems possible and wise to put a focus on disseminating knowledge to project developers, clients and customers. Furthermore, the EPC and its underlying methodology seem able to function as a design tool during the first phases of a new design and construction process.

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LITERATURE

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