"The Appliance of Innovative Energy Systems in Residential Sites; A Comparison of 11 Cases in The Netherlands"

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Abstract

In The Netherlands nearly 20% of the domestic green house gas emissions are due to the use of energy in housing. In order to mitigate greenhouse gas emissions The Netherlands adopted a policy strategy aimed at economic sectors, including the built environment. Besides policy measures that stimulate energy conservation in houses, other measures were implemented that stimulate the use of innovative techniques concerning renewable energy and energy efficiency (IES). The appliance of these innovative techniques is of special importance to the national government's long term policy goal concerning the transition to a low carbon society.

In The Netherlands experiments have been applied in order to test and stimulate the use of innovative energy systems in residential sites. They were government-funded and have been applied mainly in new-built housing projects. Although many promising techniques are applicable to existing housing, few have been applied in this particular sector. Moreover, little is known about the factors that influence the appliance of innovative energy techniques in renovation projects that involve great numbers of old houses.

In those renovation projects housing associations are the key actors, as they own housing property and have the financial assets to invest. Housing associations are private enterprises that rent houses and apartments to tenants. Although housing associations essentially carry out the public task to provide sufficient living space for low-income households, the role of housing associations has changed dramatically as they have become more entrepreneurial during the last 15 years. This was due to a policy reform in 1995 when the Ministry of Housing turned housing associations from semi-public service providers into privately operating enterprises with independent financial and decision-making autonomy.

Theoretically speaking, both the housing association and its tenants should benefit from the appliance of innovative energy systems. The housing association benefits from an improved environmental-friendly corporate image and the increase in the financial value of their housing property. The tenants benefit from the lower annual

energy bills. Although this theoretical image might look attractive, there are many practical barriers that prevent large-scale appliance of innovative energy systems.

In this paper the main research question concerns the factors and the extent in which these factors influence the appliance of innovative energy systems on residential sites during renovation projects. To answer this question an analytical framework is used that includes six independent variables: (1) policy instruments, (2) housing associations, (3) local governments, (4) cohesion between actors, (5) inter-organizational collaboration between actors, and (6) contextual factors. The framework integrates theoretical insights from policy implementation studies, diffusion–of-innovation-studies, social network theories, and organizational studies.

The analytical framework was tested by conducting a comparative analysis between eleven residential sites where neighborhood revitalization projects were carried out. The analysis encompassed two stages. In the first stage each site was treated as an autonomous case study. A comprehensive data collection was carried out, that included 70 semi-structured interviews. Additionally, qualitative and quantitative data were collected. For each project case histories were reconstructed. In the second stage the case studies were analyzed by using a comparative approach: Qualitative Comparative Analysis (QCA). This particular method combines the strengths of in-depth case-oriented approaches with comparative-variable oriented approaches. The comparative analysis was corroborated by a confirmatory analysis with bivariate correlations.

The main results of the analysis hold that the appliance of innovative energy systems on residential sites mainly resulted from local initiatives, not just policy. This is indicated by: sufficient personnel capacity (specialized in energy management) and personal motivated individuals within housing associations, collaboration between actors, and support by subsidies and communicative policy instruments. No conditions were found that were both necessary and sufficient. Furthermore, innovative energy appliances were only applied in three out of eleven projects, and due to a variety of reasons ambitions were lowered during project trajectories. Strikingly, the sites in which the innovative energy systems had been applied, were all situated in relative small-sized municipalities in which the local authorities implemented little ambitious local cli-

mate policies. Furthermore, in the projects that involved large-sized housing associations, no innovative energy systems were applied either.

The paper adds to the bodies of knowledge concerning the academic fields of the diffusion of sustainable ‘green’ innovations, environmental policy implementation, and corporate social responsibility.

Keywords: climate change mitigation, renewable energy, sustainable cities, built environment, public housing, policy implementation, policy networks, comparative analysis, mixed methods.

1. Background and problem definition

In the synthesis volume of its Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) made it clear that the effects of climate change could become catastrophic if no action is taken to reduce greenhouse gas emissions as soon as possible. The report also boldly concluded that global warming is to a large extent caused by human activities (IPCC, 2007). In order to achieve substantial cuts in greenhouse gas emissions, governments are attempting to mitigate energy consumption in several major sectors of the economy.

The built environment is one such man-made sector, one that theoretically provides ample opportunity for significant energy conservation. The application of such technical measures as insulation and innovative, high-yield heating systems mean that the energy efficiency levels of dwellings can be dramatically improved. In the Netherlands the built environment is responsible for 34% of total greenhouse gas emission. Of this emission, 56% comes from the residential sector (VROM, 2005). Greenhouse gas emissions in the residential sector are primarily caused by decentralized combustion of natural gas (in houses) and combustion of coal in power plants. In Dutch houses gas is used to for space heating, water heating and cooking. Electricity is used for lighting and domestic appliances. The housing stock in the Netherlands is rather old. The energy quality of these old houses is dramatically poorer than those that have been built more recently. To a large extent this is because legislation on energy efficiency was only implemented after 1975. Before that time, there were no standards that prescribed insulation and the installation of high-yield condensation boilers (Jong et al., 2005). Since 1975, regulation of the energy quality of new houses has gradually become more ambitious, even though it only impacts houses in their construction phase. Legislative standards and subsidies are largely responsible for responsible for both increased energy efficiency and the adoption of innovative energy system (IES) in new-built houses. However, little effort has been made to stimulate adoption of IES in the existing housing stock. By ‘innovative energy systems’ we mean renewable energy technologies and energy efficiency technologies that clearly differ from conventionally applied technologies in residential areas.

Technically speaking, adequate solutions are available to solve the problem. Domestic energy conservation up to a level of 90% is currently feasible (Trecodome, 2008).

However, it is the owners and occupiers who decide whether the application of such technical measures is desirable. When owners or occupiers consider renovating their homes they hardly prioritize energy efficiency, especially when energy costs are but a small part of the total cost of living (Sunnika 2001; Lulofs and Lettinga, 2003; SenterNovem, 2005). Moreover, the owners and occupiers have needs in regard to other issues, such as comfort, health, and their return on investment. Thus, owners and occupiers need to be pushed toward those alternatives that benefit the climate. However, in local settings it is far from easy in practice to implement policies on energy efficiency and the climate. Renovation projects in residential areas give opportunity to target installation of IES in large numbers of houses. This implies that efforts are important that aim at local stakeholders in order to negotiate trade-offs. These efforts can influence decision making by house owners and occupiers.

In this paper we will try to answer the question which factors explain the applicance of innovative energy systems in renovation projects in residential areas. Our focus lays with residential areas that are characterized by relatively low-value houses, predominantly owned by semi-public housing associations. We assume six factors relevant to explain the appliance of IES: the influence exercized by policy instruments (more specifically climate policy), the influence exercized by local governments, the influence exercized by housing associations, the influence of collaborative efforts between actors, cognitive cohesion between actors, and the influence of contextual factors. We apply both qualitative and quantitative research methods in a comparative design. Our analysis is relevant in the context of the urgent policy challenge of meeting the 2020 Dutch climate mitigation goals which includes a 20% renewable energy share in the total energy mix , and 46-50% energy conservation in the built environment.

Our paper is structured as follows. Section 2 presents a literature review of IES being applied in residential areas. Next, section 3 describes the institutional context, presenting a list of the main actors, their interests, resources, and the ways in which they interact with each other. In section 4 a theoretical framework is presented. In section 5 mentions the research design and methodology are mentioned. Section 6 reports the results of the analysis. In section 7 the conclusions of the empirical study are adressed, as well as the position of this research in relation to the context of Dutch and European Union policies.

2. Literature review on the application of IES in residential areas

Since the First Oil Crisis of 1973, many programs have been implemented to attempt to conserve energy in the residential sector. Since the late 1970s experiments in The Netherlands started with the appliance of renewable energy technolgies, such as wind and solar energy. Renewable energy technologies have the promise to radical change the socio-technical regime of energy generation and provision. Although the environmental and long-term economic benefits are known many uncertainty factors – such as long development times, uncertainty about market demand, social gains and the need for change at different levels of organizations and the wider social and institutional context – prevent large scale adoption. In fact, there is a whole range of factors that work against the introduction and diffusion of alternative energy technologies. Conditions for new markets are not present yet and clearly prevent diffusion of environmentally preferable technologies (Kemp et al., 1998). This is also true for the built environment, especially existing residential areas.

Based on exploratory case studies in urban renewal projects in the Netherlands Van der Waals et al. (2003) claim that environmental goals - such as energy efficiency - are considered of secondary importance by local stakeholders. Moreover, high policy ambitions that have been set in the start of a project are not met when the project is finished. Lack of useful and adequate policy instruments on the local level was mentioned as the main reason (Van der Waals et al., 2003; Hoppe et al. 2010). For instance, in contrast to new construction of buildings, legal standards are lacking for renovation and maintenance of the existing stock (Hoppe and Lulofs, 2008).This, however, is not just a Dutch problem as it applies to other Western European countries as well (Elle et al., 2002). Moreover, owner-occupiers in the existing residential sites are expected to act voluntarily and in cooperation with other actors. Governments on multiple levels try to stimulate IES by implementing economic policy instruments and providing sufficient degrees of information (Hoppe and Lulofs, 2008). In this regard covenants are also implemented but can be considered less effective as only those parties are attracted who are already motivated and involved (Balthasar, 2000; Van der Waals et al., 2003). However, evidence from Swiss policy evaluation shows that close cooperation between different (levels of) government does stimulate program effectiveness (Balthasar, 2000). In the Netherlands intergovernmental governance – such as the BANS-scheme - is applied as an incentive to improve local climate policy efforts. Nonetheless, indications are moderate about its effectiveness (Artentsen, 2008; Hoppe and Lulofs, 2008).

Policy programs only seldom the hold implementation of a single policy instrument. Rather sets of different and multiple instruments are implemented. The argument that a combination of instruments is necessary does not only apply to the policy field of energy conservation in the existing residential sector. Other environmental policy domains also provide evidence that policy instruments are seldom implemented independently. Rather, they are implemented together with other (types of) instruments and even seem to be effective only when they form part of a 'policy mix' (Bressers and O'Toole, 2005). However, it is true that large national programs may rely on single instruments supported by many other small instruments. The case of the National Insulation Program in The Netherlands from 1978 till 1987 shows that 90% of total budget was used for the implementation of a subsidy scheme. The program resulted in 1.8 million energy efficient houses (NIP, 1988).

More information on policy strategies and instruments is provided in section 3, which addresses the institutional context of renovation projects in residential areas. Without understanding the basic rules and power relations in local institutional contexts an analysis on the effectiveness of environmental policy instruments is useless.

3. The institutional context of renovation projects in the Netherlands

In order to understand the environment in which the energy efficiency of current houses can be improved it is necessary to gain insights in the roles of the local actors, their interests, the resources they possess and exchange, and the ways in which they interact. Opportunities for the application of innovative energy systems in the current housing stock lie in large-scale renovation projects in relatively old, post-War neighborhoods.

The houses and their environments are often characterized by poor-quality, obsolete physical construction. An additional characteristic is that the poor-quality buildings are accompanied by a poor-quality social structure. The neighborhoods are characterized by a high degree of unemployment, above-average crime rate and a high proportion of ageing residents. The population on average has a relatively low socio-economic status. Renovation projects are primarily meant to improve both social and physical structures in neighborhoods. The appliance of innovative energy systems is considered not more than a secondary objective in that endeavor. The houses in the neighborhood are for the greater part owned by one or more former public or semi-public housing associations. The housing associations manage the houses with the public objective of delivering quality housing for consumers who do not have the means to buy houses themselves. Until 1995 housing associations in the Netherlands were public or semi-public institutions, largely financed by central government. In 1995 they were liberalized, receiving financial decision-making autonomy and large lump-sums of money from national government. However, the housing associations maintained their key public goal of providing quality housing to those in society who cannot afford to buy their own house (Koffijberg, 2005).

A lot of decision making is involved when a large-scale neighborhood or building block renovation plan is being scheduled. Agreements are often laid down in covenants that cover in agreements of intent between local governments and housing associations. Local governments are able to exercise influence and encourage energy efficiency goals to be taken up by housing associations, by making tradeoffs, while strategically using urban renewal subsidies and legal permits. Nonetheless, the local authoritiy remain firmly dependent on the willingness of housing associations to cooperate. Housing associations have the most significant resources since they own the housing stock and have the financial reserves to make the investments required. Additionally, in renovation projects, legal consent is required from the tenants who live in the houses. The legal standard holds that at least 70% of the tenants must approve the renovation project plans. The legal approval rate gives the tenants some room to negotiate with their housing association. It is not surprising, therefore, that housing associations take great pains to persuade their tenants to get their plans approved. However, local governments and tenants have few means to negotiate with housing associations in to order to encourage them to install technical appliances that significantly improve energy efficiency in the houses. The power imbalance is key to the housing association's advantage when decision-making is at stake. In the end the housing associations decide - whether or not and how much - to invest in energy efficiency (Hoppe and Lulofs, 2008).

Parts of the post-War neighborhoods also contain private house owners. The owner-occupiers are often former tenants of the housing association. The housing associations sold them their houses in the years prior to the renovation project. When renovation projects are scheduled and many owner-occupiers reside in the neighborhood, the housing association(s) and municipality are often inclined to have them participate in the project. Compared to the public housing occupants, the owner-occupiers can only participate if they decide to invest their own funds (housing associations make the investments for their tenants, and are often only compensated by a small monthly rent increase, if they are compensated at all). Loans and mortgages are often so high that (low income) owner-occupiers have problems acquiring them. Access to loans and mortgages represents a serious barrier to persuading house owners to invest and participate in the neighborhood renovation project '(Clinch and Healy, 2000)'. Even when national government offers additional means to further encourage this group, the actual effect is marginal. In short, there are several institutional barriers that prevent the large-scale adoption of technical appliances to stimulate energy efficiency in existing housing (Hoppe and Lulofs, 2008).

4. Theoretical framework

Several theoretical insights are useful in showing us how to perceive and explain the phenomenon of energy conservation in the existing housing stock. These theoretical insights have their origin in a variety of disciplines, such as environmental economics and environmental psychology, diffusion-of-innovation studies, socio-technical studies and policy implementation. The last two fields are especially useful thanks to their emphasis on the application of innovative measures and their relatively widespread use in local settings.

Insights from diffusion-of-innovation studies allow us to examine the processes that underlie the dissemination and acceptance of innovative concepts in social communities (e.g., Rogers, 1962; Granovetter, 1973; Granovetter, 1978; Burt 1987). Innovative measures need to be accepted and adopted if we are to approach a sustainable society, which also involves the replacement of fossil fuels by sustainable alternatives. It turns out that this is rather difficult, however, since conventional technologies, such as those surrounding fossil fuels, are 'locked in' by means of a cluster of socially accepted system factors that represent barriers to innovative alternatives, such as sustainable energy carriers (Unruh, 2000). Traditionally, diffusion-of-innovation studies – and to a lesser degree socio-technical studies – focus on the supply side of the market and initiating processes of diffusion and change, in contrast to the demand side of the market, seeking to maintain a process of diffusion and change. The diffusion process is further complicated by the fact that the early market customers have already adopted the concept, whereas mainstream market customers still remain to be convinced to adopt the concept. Moreover, the adoption of IES is considered a co-evolutionary process, involving both opportunities and barriers deriving from both technological and social factors (Dosi, 1982).

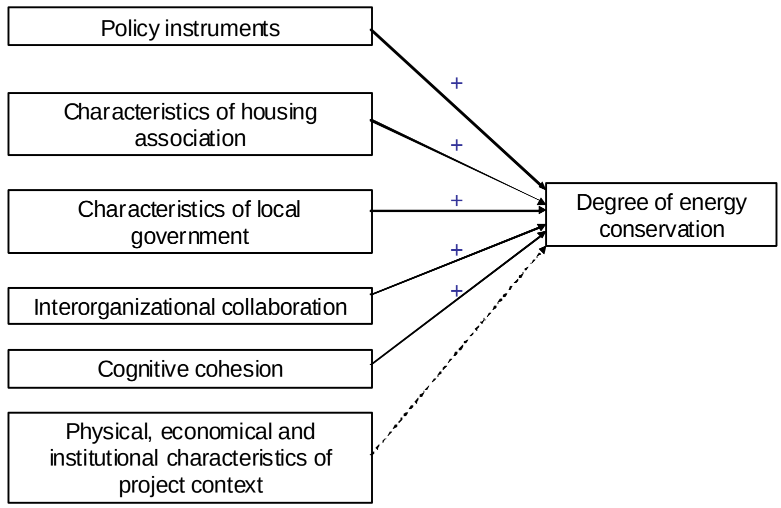
It is very difficult to convince the majority of potential adopters. The exemplary minority has already been convinced (Bressers, 1989). Conventional behavior and the existence of institutional barriers (such as sectoral policies) limit further adoption. A facilitating institutional setting is considered a precondition for continuing the process of acceptance. There are several strategies that encourage the process of acceptance, some of which have been incorporated in policy strategies and instruments. Such incentives are widely implemented in contexts where one has to deal with serious setbacks with several competing constraints originating in traditional policy domains, such as housing and spatial planning. This means that the successful implementation of policy instruments aimed at the diffusion of innovative or sustainable energy appliances is seldom self-evident.

Policy implementation studies examine the factors that explain the effectiveness of policy implementation and its products. Implementation studies originate from the 1970s and are characterized by a broad range of theoretical developments (O'Toole 2000). During the 1990s attention became centered around a few topics, such as 'policy networks' (Marsh and Rhodes, 1992; Bressers,1993; Dowding, 1995; Smith 1997; Klijn, 1996; Börzel, 1998; Bressers and O'Toole, 1998), 'network management' (De Bruijn and Ten Heuvelhof, 1995; Kickert et al., 1997), and the prospect that the horizontal 'governance' model would come to replace the hierarchic-traditional 'government' model (Bressers and Kuks, 2003). In order to encompass the broad continuum of theoretical developments in environmental implementation studies, Bressers (2004, 2009) developed the Contextual Interaction theory, which assumes that the choice and implementation of policy instruments depends on the cognition, motivation, and resources of local actors, the distribution of power between them, and the way they interact with each other in a local policy arena. Furthermore, the theory places strong emphasis on contextual factors. It also holds that environmental policy is seldom prioritized in the list of preferences held by local actors in the local context.

The study presented here uses many elements of the Contextual Interaction theory. The relevance of the theory to the domain of energy conservation in existing housing sites is that it involves the implementation of a type of environmental policy, in this case as an incentive to encourage energy conservation. The Contextual Interaction theory facilitates a systematic analysis of environmental policy implementation processes.

The insights presented in the literature review of previous policies that encourage the adoption of innovative energy systems led us to choose an approach that applies a number of theoretical viewpoints. We preferred a multi-theoretical approach to a mono-theoretical one since we assume that a multi-theoretical approach will lead to a larger explained variation. For that reason, it is useful to specify several clusters of independent variables in order to test them at a later stage. We aim to discover which cluster of independent variables delivers the most powerful explanations. We present a graphical view of our research model in figure 1.

Figure 1: Graphical presentation of the research model.



All clusters of variables are subdivided into a number of different items. These items are used as indicators of the specific explanatory model of the particular independent variable. The six clusters of independent variables concern: (1) the use of policy instruments in the domain of energy policy; (2) characteristics of local governments; (3) characteristics of housing associations; (4) inter-organizational collaboration between actors; (5) cognitive cohesion; and (6) physical, economic and institutional characteristics of the project context. This last cluster was added to the research model as a contextual component along with the other variables, which are more theoretically oriented. Without specific knowledge of the project context it is useless to analyze the outcome of policy implementation processes. Below we survey the main hypotheses in the research model. The hypotheses concern the main propositions in the analytical framework. Since the main independent variables might be operationalized as clusters comprising a number of indicators, the sub-set items are mentioned, too.

- The greater the number of policy instruments in the climate policy domain that are being implemented in the local project arena, the better the degree of energy conservation in the renovated housing stock is likely to be. The variable comprises the following items: the presence of local or regional energy conservation covenants, the use of subsidy schemes, and the use of communicative policy instruments.

- The more the organizational characteristics of local governments favor energy conservation, the better the degree of energy conservation in the renovated housing stock is likely to be. The variable comprises the following items: orientation toward environmental problems, the presence of formal energy conservation policy, personal capacity, the presence of advocates of energy conservation in housing, the degree of organizational tuning, the political orientation of the local officials, the size of the appropriate budget provided by national government, and the size of the municipality.

- The more the organizational characteristics of housing associations favor energy conservation, the better the degree of energy conservation in the renovated housing stock is likely to be. The variable comprises the following items: orientation toward environmental problems, the presence of formal energy conservation policy, personal capacity, the presence of advocates of energy conservation in housing, the degree of organizational tuning, the financial position (company capital) and the size of the housing stock owned.

- The more inter-organizational collaboration efforts that are undertaken, the better the degree of energy conservation in the renovated housing stock is likely to be. The variable comprises the following items: the presence of opinion leaders, the frequency of visits to professional meetings on the subject, and the size of the project configuration over time.

- The more cognitive cohesion that exists between organizations, the better the degree of energy conservation in the renovated housing stock is likely to be. The variable comprises the following items: cohesion in respect of the environment and sustainable development, cohesion related to the adoption of technological innovation, and cohesion in respect of the national climate policy strategy.

Contextual factors are used as control variables; hence the dotted line in figure 1. The 'project context' cluster comprises the following control variables: division of ownership rights in houses on site, total investment per house, lengthening of the exploitation term per house, type of heating system, distance to city heating facility, equilibrium in supply and demand in the market for public housing, initial energy quality of houses on location, type of house, number of houses to be renovated on site, address density, degree of public participation in the project, and degree to which energy conservation policy is institutionalized in the project's management structure.

5.1. Data collection

A number of different types of data were collected. When the study started, only quantitative data were available from a previous study on ambition-setting and energy conservation on existing housing sites (Hoppe, Bressers and Lulofs, in press). Moreover, data on the dependent variable – achieved energy conservation – were not available at that time. After the case selection stage and the pilot study were finalized, we contacted persons involved in the housing sites of interest. We made partial use of the 'snowballing' method to contact other key persons in the cases, after which dates were set for in-depth interviews. Forty on-site interviews and 30 telephone interviews were conducted. Some additional documentation on the cases was traced before the interviews were conducted; more was found after access was provided by the interviewees. The project documents found included formal policy documents, advisory reports, annual reports, specific information papers, websites, feasibility studies and geographical maps of project locations.

The group of interviewees featured predominantly persons from the following professions: project manager at the housing association, project leader in the local authority (urban renewal, property development), civil servant dealing with environmental or energy/climate affairs in the local authority, or energy associate in the housing association. The high incidence of these professions was beneficial to the researcher for three reasons: (1) most interviewees were involved in decision making on the subject of energy conservation in the projects of interest; (2) they were often involved in the project for relatively long periods, meaning they were very knowledgeable and experienced; and (3) they possessed good networks with many contacts of interest to the researcher. Finally, it is worth noting that most interviewees were males in the age category 40-50, with higher education (most frequently in civil engineering).

5.2. Data treatment

The quest for comparison of 11 cases meant that analysis by qualitative means alone was out of the question. The number of cases required a predominantly quantitative analysis. Data treatment was of great importance to the comparative analysis (see Note 2).

The recorded interviews were written down in transcription reports. It was decided to use near-literal transcription reports in order to make full use of the richness of the data collected. After data collection, transcription reporting, supplementing ambiguities in data sources and story lines, it was time to construct case histories. After the case histories were completed, the phase of quantitizing qualitative data began. (However, many quantitative data were already present in the cases.) Ten-point scales were constructed and scores were assigned per case. A data matrix was thus created, meaning that careful attention had to be paid to case histories and case-specific data in order to fill in the data reliably. A code document was designed for construct validation and reliable score assignment. This process had to be carried out in a reliable manner, so all score assignments were augmented with textual argumentation. Subsequently, the score assignment was replicated to check reliability and consistency.

5.3. Data analysis

Data analysis in the comparative research design was characterized by phasing, the use of different types of research methods, and the use of different types of data. The analysis featured both qualitative and quantitative methods to allow the cases to be compared. Qualitative and quantitative methods were used to compensate, meaning that ‘mixed methods’ have been applied, a methodology that derives from an epistemologically pragmatic stance (Johnson and Onwuegbuzie, 2004). The objective of applying both qualitative and quantitative methods in comparative research is to confirm analytical results where possible (triangulation), improve the researcher’s interpretation, and optimize the sample (inter alia).

The qualitative analysis features crisp-set qualitative comparative analysis (csQCA). QCA (Ragin, 1987, 2000) is a method designed to bridge the divide between variable-oriented and case-oriented comparative research designs. Variable-oriented case analyses suffer from the disadvantage that the analysis is narrowed down to a limited number of variables, whereas cases often provide a 'thick description' with a large number of variables. Variable-oriented case analyses leave little room for specific cultural and historical aspects. The disadvantage of case-oriented analyses is that causal patterns cannot be compared between cases. QCA positions itself between the complexity of case-oriented approaches and the generalization of variable-oriented ones. The method is of particular importance when one wants to compare causal patterns with a medium-sized number of cases (10-50). Both qualitative and quantitative data can be applied. After coding the data into binary data - either present ('1') or non-present ('0') - a data matrix is developed. In QCA a data matrix is called a 'truth table'. Truth table analysis allows researchers to make statements about necessary and sufficient conditions that arise if a certain dichotomous social phenomenon is to occur. QCA also enables the researcher to make statements about combinations of conditions that enable the occurrence of a social phenomenon under investigation. QCA results – i.e., such causal patterns as are found - enable the researcher to either develop theories or to test or build upon existing theories. Here QCA is applied in light of the richness of information on the cases and because the dependent variable is a dichotomy: an innovative energy system is either applied ('1') or not ('0'). The software package fsQCA 2.2 (Ragin et al., 2007) was used to compute the analysis.

Bivariate correlations were computed to confirm the results from the QCA. Regression analysis could not be performed because of the dichotomous dependent variable. The small number of cases (n = 11) necessitated the use of a 90% confidence interval. Since we predicted the direction of the correlations, one-tailed tests were computed.

6. Analysis and results

This section presents the results of the comparative analysis. We have chosen to present the results in stages. First of all we present an overview using descriptive statistics involving means, extremes, range, standard deviations and skewness of distribution. Furthermore, important data are presented per case in an inter-case matrix. The results of the multiple regression analysis are presented thereafter. To start the overview of the results, a geographic map of The Netherlands is presented in figure 2, showing the locations of the sites studied.

Figure 2: Geographical locations of cases studied in the Netherlands.

6.1. Case characteristics

The important numerical data are summarized per case in table 1. The data include the number of houses renovated, the type of house, the ambition set for energy conservation (in EPL-scale points), the scale of the energy performance achieved (in EPL-scale points), the actual energy conservation achieved (in EPL-scale points), and the relative energy conservation achieved (as a percentage). It also presents information on innovative energy systems that were part of the planning stage of projects and actual application in the realization stage of the project. Table 1 is structured in descending sequence according to the category ‘relative energy conservation achieved’.

Table 1: Key numerical data in cases.

#	Name of site	Name of town	Number of dwellings	Dwelling type	Degree of energy conservation	IES (ambition)	IES (actually implemented
1	Groot Kroeven	Roosendaal	246	Family house 1960s	69.8%	Several options considered	Passive housing standards applied
2	Eygelshoven	Kerkrade	300	Family house 1950s	51.1%	Several options considered	None
3	Europarei	Uithoorn	635	Appartment 1960s	50.2%	Solar heating	Solar heating and air heat pump
4	Prinsenhof	Leidschendam-Voorburg	1628	Appartment 1960s	43.8%	Several options considered	None
5	Hogewey	Weesp	258	Appartment 1960s	35.0%	Several options considerd including heat pumps / geothermal	Fleece wall and decentral cogeneration
6	Espels	Leeuwarden	117	Family house pre-War	34.%	None	None
7	Binnenstad-Oost	Helmond	121	Family house pre-War	32.9%	None	None
8	Tannhäuser	Apeldoorn	100	Appartment 1960s	32,9%	City heating from biomass plant	None
9	Bijvank het Lang	Enschede	854	Family house 1970s	30.5%	City heating for heating water	None
10	Nieuwstad	Culemborg	200	Family house 1970s	30.1%	Several options considered	None
11	Atol- en Zuiderzeewijk	Lelystad	380	Family house 1960s	26.5%	None	None

The site with the smallest amount of energy conservation achieved had a value of 26.5% (Atol- en Zuiderzeewijk), while the site with the largest amount of energy conservation achieved had a value of 69.8% (Groot Kroeven). In the latter case the innovative concept of passive renovation (the renovation variant of passive housing) had been applied, a technology that features extreme insulation standards and the use of passive solar energy. The technique has only rarely been applied in The Netherlands, most often in renovation locations. On average the sites feature 440 houses subject to renovation. The location with the smallest number of houses subject to renovation counted 100 houses (Tannhäuser), whereas the largest site counted 1,628 houses subject to renovation activities. The standard deviation here is rather large (459), due to the fact that the distribution of the category is very right-asymmetric (2.071). Most cases are close to the mean, whereas one site (Prinsenhof) has many houses. The differences in types of houses are also worth mentioning. On seven sites the houses were family houses built between the 1930s and the 1970s. On four sites the dwellings were apartment buildings, built in the 1960s. When selecting the cases it was not possible to make allowance for any variance in the type of housing. Nonetheless, the variance analysis did not show any significant difference from a larger sample of housing sites according to the type of house. The average total investment per house was rather high at € 62,383 (given that € 100,000 is sufficient to build a new family house). The investments ranged between extremes of € 25,000 and € 105,078. This too is quite a large variation. The last category in the table refers to exploitation term lengthening. This category is included in the table because lengthening the exploitation term is a criterion that housing associations often use as a means to compensate for less profitable investments (equipment to encourage energy efficiency is often considered to fall in this category). Exploitation term lengthening was 34 years on average, which is more than half the lifetime of a house in the Netherlands. The average level of energy conservation achieved in the cases that have been investigated is 39.7%.

6.2. Case histories of successful IES application

In 8 out of 11 cases the application of innovative energy systems was investigated and taken into consideration in the early stages of the project. Typically, this stemmed from the use of financial subsidies provided by national government, allowing an energy audit to be conducted and reported, including recommendations to improve the location’s energy performance. The results were integrated in the project plans and laid down in the ambitions. However, the application of IES was not a main concern in all 11 cases. Kin fact this happened in only one case, and even then not right from the start. In the Groot Kroeven case the concept of ‘passive renovation’ (the renovation alternative to passive housing) was adopted and afforded considerable weight, although passive renovation was never part of the initial project plans. Innovative energy systems were applied in 3 of 11 cases: Groot Kroeven, Europarei and Hogewey. The histories of these three cases are summarized below. Reporting the histories of cases where IES have not been applied would make this paper too long, so they are not reported. We have, however, summarized the particular reasons why they were not utilized (see table 2).

Groot Kroeven

Fears for neighborhood degradation led in the late 1990s to plans being made by the housing association and the municipality to renovate existing houses and re-develop (demolish and rebuild) many others. In 2003 the local authority of Roosendaal commissioned an external bureau to do an energy audit. This study was subsidized by national government. The report recommended collective biomass installations and heat pumps. It especially addressed innovative energy improvements in newly constructed houses. There was little emphasis on improving the existing stock. Although the report’s advice was initially accepted by the municipality it later dropped under the horizon as the environmental manager was not supported by colleagues from other departments and their aldermen. The housing association considered that the report’s advice was not feasible and never considered the options seriously.

At the same time a highly motivated project manager was appointed in the housing association, who had close connections within networks interested in improving the energy performance of houses. The networks’ interest especially addressed the concept of ‘passive housing’ (See note 3), and its renovation version ‘passive renovation’. The network involved both professionals and practitioners. Most importantly, the network facilitated dissemination of knowledge and experience in the application of passive houses in other countries, partly by experienced by housing associations. So in this way knowledge diffused in from successful projects in

Germany and Austria. Important knowledge was provided about the solution of many related problems, such as dealing with higher material costs and time lost due to new passive housing materials, which require new standards. The project manager used a subsidy scheme allocated by national government to promising energy-related experiments in the built environment (EOS-GO), which increased the project budget by 1 million Euros. It was necessary to gain this subsidy to convince the executive board of the housing association. Although an important foothold was created, the tenants of the existing houses in Groot Kroeven needed to be convinced, since renovation projects require that at least 70% of the households involved approve the plans. These people needed to be convinced as it became clear that monthly rents were to increased to make the 'passive renovation' plans feasible. Another grant was obtained from national government which allowed a trip to be organized so that members of the households affected could visit successful residential areas with passive houses. This allowed them to gain experience from foreign households in the practice and benefits of living in a passive house.

To gain practical experience, three experimental houses were renovated according to the strict passive housing standards (after two passive houses had been newly built), prior to renovation of all 246 houses on the site. This was deemed necessary by the housing association board, as a feasibility test. The Technical University of Eindhoven monitored the experiment, which in turn created a professional third-party image. The experiment encountered several practical hurdles that needed to be overcome. For instance, Dutch material providers were not able to deal well with the strict passive housing standards (which are much more strict than the contemporary national legal building material standards). New windows had to be developed which required testing, which led to delay and additional costs. Secondly, because 'passive renovation' was new to The Netherlands, specialized, experienced advisers and contractors from Germany were contracted as they had already built up a reputation in previous years. In the meantime the project received recognition from the regional environmental government of West-Brabant. A covenant, a provincial award and media attention following initiatives of the regional environmental government drew more attention to the project, followed by interest from all areas of The Netherlands. Although many barriers were overcome, one major problem remained: convincing the households. Following project delays and talk about increased monthly rents, consensus about the project was dwindling. Nonetheless, the 70% approval standard was finally met, albeit only just.

Europarei

The residential area of Europarei consists of apartment buildings dating from the late 1960s. Problems in the neighborhood during the late 1990s indicated a need for revitalization. As the original plans to demolish and rebuild the apartment buildings had led to great local commotion, followed by their rejection, the housing association developed plans to renovate the existing apartments. At the time, the housing association had specialized, highly motivated staff looking after energy affairs. During the initial stages plans were set to install renewable energy systems. In the project a special renewable energy project group was formed consisting of members drawn from the housing association, the local authority, the consulting agency (specialized in applying IES in buildings) and a national government agency. This interorganizational group was to continuously follow the remainder of the project, which enabled ongoing attention to renewable energy systems between stages in the project (one apartment building was to be renovated every year). Subsidies were acquired from national government to have energy audits performed and an advisory report drafted by third parties. After solar heating and air heat pumps became serious options, feasibility studies were conducted.

Although the housing association's ambitions were high, the problems – financial, physical construction and convincing the tenants – led to a failure to apply innovative energy systems in the first three apartment buildings. However, lessons were drawn from those experiences. Although the housing association board backed the project manager's renewable energy ambitions, they demanded that an additional budget be acquired. A subsidy from the provincial government for renewable energy systems was acquired, adding an external budget for the plans' execution. The municipality played an active facilitating role, which was necessary to acquire the subsidy. The subsidy was time-related and this problem solved practically, partly thanks to the close collaborative ties between the local and the provincial government, which had become partners in a 'provincial climate covenant'. An excursion to inspect the successful application of solar heating systems in comparable apartment buildings (and residential areas) in Amsterdam was organized to convince members of the housing association's executive board.

Solar heating systems and air heat pumps had been successfully installed on two apartment building in Europarei in 2007 and 2008. This successful implementation led to greater levels of ambition in the housing association as plans were set install solar PV systems in four apartment buildings that were to be renovated at a later stage. Although the provincial government was only able to subsidize the installation of solar PV on two of them, the housing association decided to have the latter two equipped, too, as it decided to carry the whole investment, even without a subsidy being granted. Nonetheless, our assumption is that would not have been possible without the experience gained in the previous years, when subsidies were necessary.

Hogewey

Similar to the previous case, apartment buildings from the late 1970s were in need of renovation, arising from intensive maintenance and fears of neighborhood degradation. In this case the renovation of two buildings was involved. Plans for renovation were made in the early 2000s, drafted by the local authority and the housing association. As in the previous cases, energy audits and an advisory report were subsidized by national government. The reports were handed over in 2003. Besides insulation, the reports proposed innovative energy systems, such as a decentral biomass plant. However, the members of the project's steering group argued that the alternatives advised were not feasible in a residential area. This decision meant that local and national government were no longer involved in the project. The local authority disengaged due to lack of capacity (the municipality is small), and previous adverse experiences with local and regional efforts to encourage renewable energy – for which they put a great deal of blame on national government for its lack of support. When energy performance in the housing sector is at stake the local authority prefers new construction projects to revitalizing existing ones.

In 2005 the first of two apartment buildings in Hogewey was renovated. A highly motivated project manager was in charge of operations. He possessed positive experience, since in past projects he had implemented innovative energy systems for previous commissioners. This also involved connections with innovative contractors.

The plan was to apply a ‘fleece wall’ – a transparent, multi-functional glass wall that both insulates and provides passive solar heat to existing apartments. An additional advantage of this construction is that thermal bridges - caused by former balconies - were removed. However, the ‘fleece wall’ came at a cost and the housing association’s executive board demanded that an additional, external budget be found. A subsidy was therefore acquired from national government under the urban renewal policy. This was a clever move by the project manager, as he submitted a proposal for a subsidy scheme initially designed to reduce noise nuisance in urban renewal projects. The apartment building was located near a heavily trafficked road that did indeed cause a lot of nuisance to the tenants in the apartments. This justified the use of the subsidy, although the application of the ‘fleece wall’ had multiple benefits, especially with regard to energy efficiency.

A second apartment building was to be renovated later. In the planning stage the housing association aimed to have a geothermal heat pump system installed, but this required maintenance to the collective heating distribution system. The tenants complained about the collective heating distribution system, as they perceived the costs unequally divided. At the same time the project was delayed, for reasons unrelated to the energy efficiency plans. This increasingly caused irritation among the tenants. Using heat pumps would require the provincial government to provide a legal permit to use ground water (acquifer). Running through the permit procedure would take at least six months – an additional delay to the project and one the tenants deemed unwarranted. The aversion to maintaining the collective heating system and expected further delay due to the permit application procedure led the project group to drop the heat pump idea. However, the housing association decided that something was needed in compensation. High-yield, decentral cogeneration condensation boilers were installed in the apartment building in 2007. Strikingly, the housing association did not require any additional external budget to be made available. No subsidy request was ever made. Representatives of the housing association argued that the purchase and installment of the decentral cogeneration condensation boilers was a timely response to recent market developments. Nonetheless, a national government subsidy was used for conventional thermal insulation on the same apartment building.

This latter can be considered a typical example of a subsidy designed for the use of conventional measures, rather than innovative alternatives.

6.3. Reasons for not applying IES

In the remaining eight cases IES were not applied. In five of those cases innovative energy cases were originally planned but the application failed to make it through to the realization phase. Table 2 summarizes the reasons for non-application of innovative energy systems. IES in the successful cases, originally planned but not implemented, are also addressed. Although a list of reasons for non-implementation is given, there is no similar list for implementation. The analysis of successful implementation involves QCA and is addressed in the next section.

Table 2: Reasons for not applying IES.

Reason for non-application of IES	**Frequency and case(s)**
The establishment of a biomass plant near the project location was canceled.	1 (Tannhäuser)
A lack of trust occured between the local authority and the housing association, which led to the loss of 'renewable energy' as an item on the project agenda.	1 (Nieuwstad)
The tenants did not favor the maintenance of the collective heating system. They were afraid that the energy costs were not to be divided proportionaly. This led to a decision in favor of individual heating systems.	2 (Prinsenhof, Hoegewey)
The advices deriving from the energy audit were never taken into account. They only resembled a symbolic meaning.	2 (Eygelshoven, Binnenstad-Oost)
The tenants did not an increase in their monthly rents which was a reason for their housing association to renounce any options to apply renewable energy systems. The housing association did not want to make any uneconomically investments.	1 (Bijvank het Lang)
The renovation project had been delayed in the initiation stage, and the tenants were tired of waiting. The speeding up of the project did not leave any room for the procedure to get the legal permit to use ground water in order to apply heatpumps on geothermal energy.	1 (Hogewey)
The application of innovative energy systems was never a serious consideration to the project planners. The ambition was never better than the conventional measures being aplied. The housing association also did not bear the financial assets to make such an investment.	2 (Atol- en Zuiderzeewijk)
A bad experience with the application of an energy efficient system in a previous project led to a 'deadlock' concerning application of the like systems. Concerns regarding financial feasbility were the main reason.	1 (Prinsenhof)

The application of a biomass fired energy generation plant in residental areas was not considered a feasible option.	2 (Hogewey, Groot Kroeven)

6.4. Results of the empirical analysis of the appliance of IES

Qualitative comparative analyses of the different variable clusters were conducted to identify the causal drivers behind the phenomenon that IES were applied.

Results on the cluster 'instruments of climate policy'

Two conditions were identified as necessary but not sufficient in case IES were applied: subsidies and communicative policy instruments. Case histories provide the insight that IES might also be applied without subsidies, but only after IES had previously been applied successfully after subsidies had been used. Positive experiences from subsidized projects taught that housing associations learned to perceive and appreciate the benefits of IES, in such a way that application without subsidy became feasible. Moreover, subsidies were necessary as stepping stones, but after experience was gained, housing associations dared to invest the total amount themselves and subsidies were no longer necessary. A sufficient degree of information was also necessary, as demonstrated by energy audits and information from national government. Covenants had little impact, although they clearly had beneficial supportive functions in some cases.

Results on the cluster 'organizational characteristics of the housing association'

Two necessary but not sufficient conditions were found: the presence of 'advocates' and staff specialized in energy affairs. In all three cases in which IES were applied, a highly motivated, influential project manager was in charge of operations in the renovation projects. In addition, combinations of conditions were identified that preceded the application of IES. Most include alignment between departments, financial reserves and formal energy policy. Alignment between departments within the housing association and formal policy were involved when IES were not applied, however. Further investigation led to an explanation stemming from recent reorganizations, a typical social housing sector factor, mergers, and the increasing scale of the housing associations.

Results on the cluster 'organizational characteristics of the local authority'

Three necessary but not sufficient conditions were found for non-application of IES: specialized staff in energy affairs, fine-tuning between departments within the local government, and intergovernmental policy support (the so-called 'BANS' scheme). These conditions also correlate strongly between themselves. Strikingly, the intergovernmental scheme – designed to stimulate the design and implementation of local climate policy – rather hinders than stimulates the application of IES in existing residential areas. Further investigation in the case histories teaches that IES are considered feasible in sites with newly constructed houses, but not so much in existing areas. Many other predominantly social project goals are afforded greater weight. Secondly, there is an easier and quicker return on investments from developing and selling new houses than renovating existing ones, which are perceived as unprofitable. Moreover, IES were successfully applied in renovation projects in small-sized municipalities in which the local authorities showed little ambition for the implementation of local climate policies.

Results on the cluster 'interorganizational collaboration'

Two necessary but not sufficient conditions were identified: presence of 'opinion leaders' and frequent visits to thematic meetings. These meetings concern recent developments in renewable energy technologies and energy efficient systems, and involve both experts and practitioners. In our cases they were organized by national, regional governments or NGOs, and enabled 'cross-fertilization'. Without the combination of the presence of a highly motivated, authoritative person close to the decision making organ (the opinion leader), and frequent visits to thematic meetings, important information is not diffused, which is critical to the application of IES.

Results on the cluster 'cognitive cohesion'

No necessary or sufficient conditions were found in this cluster. Only a combination of the conditions concerning (high) environmental orientation and (high) adoption of technical innovations orientation preceded successful application of IES.

Results on the cluster 'contextual factors'

Two necessary conditions were identified. In the first place, policy support from urban renewal policy disabled successful implementation of IES. IES were not implemented in locations where local or even national government had any influence on the locus of urban renewal policies. On the contrary: locations where IES were successfully applied were all similar in their lack of large neighborhood revitalization plans, with a concomitant lack of government influence, which meant that housing associations exercised greater independence.

Relatively large investments per house renovation facilitated the application of IES. This can be interpreted as a 'sunk costs' argument. When the opportunity occurs, additional IES measures can be taken to improve the house. Because a large investment is being made anyway, the burden of the additional measure is relatively light. By contrast, lengthening the term of exploitation – a measure that is often mentioned to make investments profitable - does not influence IES.

With regard to the item 'participation', a high value could not be identified as a necessary condition. No IES were installed in combination with high address density and a large number of houses on location. For example, in the Prinsenhof case, tenants were asked to vote whether to maintain the collective heating system or not. Maintenance of the collective heating system is a precondition for applying IES, and is even cheaper than the alternative of individual heating systems. Although the housing associations presented information that actually demonstrated the significant financial benefits of the collective systems (€10 per month) the tenants outvoted the alternative of maintaining the collective system. Furthermore, several combinations of causal, context-related items were found that went against the installation of IES: address density, (large) number of houses on-site and the (large) share of newly built houses on-site.

6.5. Confirmatory analysis with bivariate correlations

The results from the qualitative comparative analysis were investigated by computing bivariate correlations in order to confirm or disconfirm the results. Because QCA does not allow for scaling techniques, the separate underlying items of the variables in the box were analyzed. The results of the analysis are presented in table 3.

Table 3: Bivariate correlations

Cluster 'policy instruments from the domain of climate policy'.

Indicator name	r	p
Use of communicative policy instruments	.465	.075
Presence of local or regional covenants	-.056	.435
Use of subsidies	.759	.003**

Cluster 'characteristics of the local authority'.

Indicator name	r	p
Financial support by national government (BANS)	-.639	.017*
Political orientation of the officials	-.227	.251
Orientation towards the environment	-.562	.036*
Membership of Climate Treaty	-.542	.043*
Size of the municipality	-.477	.069
Organizational fine-tuning	-.659	.014*
Personnel capacity	-.412	.104
Formal climate policy	-.304	.182
Presence of energy efficiency advocates	-.116	.367

Cluster 'characteristics of the housing association'.

Indicator name	r	p
Financial position	-.083	.404
Organizational fine-tuning	-.088	.399
Number of houses in property (size of stock)	-.303	.182
Formal climate policy	-.194	.284
Presence of energy efficiency advocates	.717	.006**
Orientation towards the environment	.132	.350
Personnel capacity	.453	.081

Cluster 'inter-organizational collaboration'.

Indicator name	r	p
Frequency of visits to thematic meetings	.597	.026*
Size of the project configuration over time	.473	.071
Opinion leadership	.607	.024*

Cluster 'cognitive cohesion'.

Indicator name	r	p
Cohesion towards the national climate policy strategy	.076	.422
Cohesion towards environment and sustainable development	-.309	.178
Cohesion towards technological innovation adoption	.155	.325

Cluster 'project context'

Indicator name	r	p
Exploitation term lengthening of renovated houses	.016	.481
Distance to district heating facility	-.218	.259
Support by urban renewal policies	-.761	.003**
Number of houses	-.086	.401
Equilibrium in public housing market	-.403	.109
Institutionalization of energy efficiency in decision-making process	-.231	.247
Initial energy quality of houses	.286	.197
Degree of public participation	.364	.136
Type of heating system	.256	.224
Distribution of property ownership	.348	.147
Address density	-.225	.253
Share of newly built houses	-.341	.152
Investment per house	.754	.004**

Analysis on the variable 'instruments of climate policy' revealed two significant items: subsidies (r = .759; p = .003) and communicative instruments (r = .465; p =

.075). Analysis of the characteristics of the housing associations found two significant items: presence of an 'advocate of energy efficiency' (r = .717; p = .006) and staff specialized in energy affairs (r = .453; p = .081). Analysis of the influence of local authorities revealed four significant items, although the direction contrasts with the hypothetical prediction: intergovernmental scheme BANS (r = -.639; p = .017), internal alignment (r = -.659; p = .014), environmental orientation of government (r = -.562; p = .036), and membership of the Climate Agreement (r = -.542; p = .043). Analysis of interorganizational collaboration found three significant items: opinion leadership (r = .607; p = .024), frequency of visits to theme meetings (r = .597; p = .026) and size of the project configuration over time (r = .473; p = .071). Analysis of the items on cognitive cohesion found no significant correlations. Analysis of the influence of contextual factors found two significant items: the amount of total investment per house (r = .754; p = .004) and the degree to which urban renewal policies addressed the location of investigation (r = -.761; p = .003). The latter contrasts with the predicted direction of the hypothesis. The results of the confirmatory analysis are presented in table 4. All results from the QCAs are confirmed.

Table 4: results of confirmatory analysis between QCA and correlational analysis (plus size of direction regarding the correlation).

Variable cluster	**Items identified csQCA as necessary conditions**[1]	**Confirmatory analysis**
Instruments of climate policy	Subsidies (+) Communcative instruments (+)	Confirmed Confirmed
Organisational characteristics of the housing association	Advocate for energy efficiency (+) Staff specialized in energy affairs (+)	Confirmed Confirmed
Organizational characteristics of the local authority	Intergovernmental scheme BANS (-) Internal alignment between departments (-)	Confirmed Confirmed
Interorganizational collaboration	Opinion leadership (+) Frequent visit of thematic meetings (+)	Confirmed Confirmed
Cognitive cohesion	None	Confirmed

[1] Excluding combinations of conditions enabling IES.

Contextual factors	High investment per house (+) Urban renewal policy support (-)	Confirmed Confirmed

6.6. Interpretation of the results

No condition was found that was both necessary and sufficient. Interpretation of the analysis of non-application of IES provides two further results of interest. Some statements need to be made when addressing the clusters of variables. First, the clusters 'instruments of climate policy', 'organizational characteristics of housing associations' and 'interorganizational collaboration' contained significant items that correlate positively to the application of IES. This is in conformity with our expectations. The cluster 'characteristics of the local authority' did have significant items, but contrary to the directions we hypothesized. These results are surprising, and may disprove the interpretation of the degree to which local authorities exercise an influence over the local application of IES in renovation projects in existing residential areas. We did not identify significant items in the cluster 'cognitive cohesion'. However, a combination was found that positively correlates with the application of IES. Finally, the cluster on contextual factors had two significant items, one in the positive and one in the negative direction.

In summary, IES were not applied in the absence of a sufficient degree of collaboration, in the absence of a sufficient number of policy instruments, when positive characteristics of local authorities were present, and when positive characteristics of housing associations were present. The latter two are in contrast to our expectations. One might expect that organizations with plenty of staff, formalized energy policy plans, and intergovernmental budgets for local climate policy would be more likely to have IES installed, but our results do not confirm these views. Necessarily, these findings need further elaboration.

7. Conclusion

Although innovative renewable energy and energy efficiency technologies offer great opportunities to improve energy efficiency in residential areas and decrease GHG emissions, little has been achieved recently in The Netherlands. Conventional appliances and energy systems are often used for a number of reasons, having to do with different barriers that block the adoption of more innovative and sustainable alternatives to further energy efficiency. In this paper we have tried to answer the question of which factors explain the application of innovative energy systems in renovation projects in residential areas. We sought six theoretical explanations: the influence exercised by policy instruments, the influence exercised by housing associations, the influence exercised by local governments, collaborative efforts between actors, cognitive cohesion between actors, and contextual factors.

Policy instruments were found to be of prime importance to the appliance of innovative energy systems. Subsidies and communicative policy instruments were necessary but not sufficient conditions. Covenants were neither necessary nor sufficient. Rather, they arose out of previous projects and local experiments. The analysis showed that *housing associations* were primarily involved with social issues (their prime business). When the application of IES was at stake the executive board demanded that external finance, such as subsidies, be acquired. The privatization, starting in 1995, might be the reason why the housing associations discount every investment harshly. However, this trait can be combined with application of IES if two conditions are met: there has to be a highly motivated and influential project manager, and there has to be a staff specialized in energy affairs. Although the adoption of corporate social responsibility standards among housing associations is rising, the application of IES can be considered more a personal motivation by individual managers within housing associations than one that derives from the executive board following a formal policy document or CSR statement. Furthermore, in our cases IES were only installed when relatively small-sized housing associations were involved. This might be an indication that larger ones have too many other concerns to worry about, given the size of their organization and housing stocks they manage. The role of *local governments* was rather limited, as they only exercised influence in the planning stages of projects or played minor supportive roles. Strikingly, the successful projects were all located in relatively small municipalities within which lay only local authorities with small staffs and that likewise lacked the capacity to pay much attention to local climate policy, including the installation of IES in residential areas. *Tenants* turned out to be little concerned with the energy efficiency of their homes. In some cases they actively preferred conventional, suboptimal systems over more energy efficient alternatives, even though additional information was provided on direct financial benefits. The reason for this lies in a fear of increased and equally divided energy costs and distrust of the housing association's plans. With regard to *interorganizational collaboration* it can be stated that without the presence of a highly motivated, authoritative person close to the decision making (the opinion leader), combined with frequent visits to thematic meetings, important information is not diffused, which is critical to the application of IES. Two *contextual factors* were important: a large total investment per house, and policy support concerning urban renewal activity. The latter wields a negative impact, indicating that urban areas troubled by a plethora of social problems do not provide optimum conditions for meeting environmental goals such as the application of IES. Moreover, three variables exercised a clear, positive influence on the application of IES: policy instruments (climate policy), housing associations' organizational characteristics, and interorganizational collaboration.

The study has shown that applying innovative energy systems to the existing housing stock remains a very complex, difficult task. Harvesting the technical potential for energy efficiency is far from being an accomplished goal. Future research and policy-making should devote careful attention to the way local actors should be addressed in order to gain commitment (from both households and housing associations), and to see how local authorities may actively facilitate the project of furthering energy efficiency in housing renovation sites, and not just by setting ambitious goals. Furthermore, systematic, in-depth comparison of local level projects, as well as international comparative analyses are necessary to assist the Dutch national government, the European Union and the OECD to develop policy instruments and strategies that encourage actual, local housing renovation projects.

Footnotes

Note 1. The following variables were checked for significant differences in means between sample and sites in national monitor dataset: size of the municipality ($F = .841$; d.f. = 32; $p = .366$); local authority's financial support provided by national government ($F = .022$; d.f. = 32; $p = .882$); size local authority's urban renewal budget ($F = 3.863$; d.f. = 29; $p = .059$); number of houses on site ($F = .172$; d.f. = 32; $p = .682$); ambition formulated for energy performance of site ($F = .436$; d.f. = 28; $p = .515$); share of houses on site to be newly built ($F = .464$; d.f. = 32; $p = .501$); number of houses on site to be newly built ($F = 2.402$; d.f. = 32; $p = .131$); type of energy provision ($F = .000$; d.f. = 32; $p = 1.000$); local authority's score on national sustainable development index ($F = .059$; d.f. = 29; $p = .810$); local authority's collaboration efforts towards local actors ($F = 1.289$; d.f. = 29; $p = .266$); political orientation of local officials ($F = 3.242$; d.f. = 32; $p = .081$); mean financial value of dwellings on site ($F = .242$; d.f. = 32; $p = .626$); address density on site ($F = 2.555$; d.f. = 32; $p = .120$); participation of site in national urban renewal program '56 wijken' ($F = 1. 92$; d.f. = 32; $p = .264$). The confidence level used was 95%.

Note 2. This does not imply that we regard data treatment for qualitative analysis as unimportant.

Note 3: The 'Passive housing' is an integral concept that combines several measures that improve energy efficiency of houses. It combines high quality insulation, mechanic ventilation with heat re-capture, orientation towards the sun. Sometimes, solar heating and –PV systems are installed additionally. The standards are high: the limit is 15 kWh/m2 floorspace annualy.

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