MASTER

Instruments for successful energy neutral housing developments
lessons for Eindhoven from the Danish and UK municipalities

Kadarpeta, S.S.R.

Award date:
2010

Link to publication
Instruments for successful energy neutral housing developments

Sahul Reddy Kadarpeta

Construction Management and Engineering

2010
Instruments for Successful Energy neutral housing developments

Lessons for Eindhoven from the Danish and UK municipalities

Master Graduation research
In Partial fulfillment of the requirements for the degree of
Master of Science in Construction Management & Engineering

Student
Sahul Reddy Kadarpeta

Chairman graduation studio
Prof. dr. Ir. Wim Schaefer

Supervisors
Prof. dr. ir. Bauke de Vries, TU/e
Dr. Qi Han, TU/e

Presented on
26 August 2010
Energy neutral housing developments
EXECUTIVE SUMMARY

ABSTRACT
Netherlands has set national energy targets for year 2020. In this context at the local level Eindhoven Municipality has set its ambition to go energy neutral in housing sector by 2020 and decided to develop new energy neutral housing areas. Lack of strict regulations and appropriate forms of support aimed at relevant stakeholders involve has attributed to the lack of acceptance for energy neutral housing in the housing market. Further lack of a defined role for municipality to promote stakeholder participation has affected the realization of energy neutral housing developments. Desk research shows that Denmark & UK have introduced effective regulatory & support instruments to promote their energy ambitions in housing sector. Danish municipalities have played a unique role to promote stakeholder participation in energy efficient housing developments. These instruments found from research are prioritized for Eindhoven scenario as per stakeholder preferences using Analytical Hierarchy process. Using scenario analysis a proactive participatory role is found necessary for the Eindhoven municipality to promote stakeholder participation in energy neutral housing development process.

Key words: Energy Neutral Housing, Support & Regulation Instruments, Role of Municipalities, Analytical Hierarchy Process, Scenario analysis

INTRODUCTION
Eindhoven municipality has expressed its vision to go energy neutral in the built environment, specially housing sector, by 2020. Proven technology to realize energy neutral housing developments is available, but however practical realization of energy efficient housing developments has not been achieved yet.

The research by Beerepoot, 2007 shows that a broad scale adoption of energy efficiency measures fails to occur in the existing Dutch housing sector, which has resulted to the lack of structural cooperation between different actors in the mainly project-based building sector. The Dutch policy instruments have failed to instigate the adoption of energy efficiency, renewable energy & carbon reduction measures for energy neutral developments. The research conducted by Hans, Ingmar, 2008¹ on Groningen’s CO2 neutral ambitions shows that serious investments and/or collaborations of all stakeholders is necessary for such projects to become practically feasible. The energy neutral housing ambition of Eindhoven is being affected due to lack of strict regulations & support instruments, lack of effective collaboration between stakeholders which have resulted in lack of market demand for energy neutral houses. Thus Eindhoven municipality is looking learn from the right examples which have been proven in practice and also from active developments currently taking place.

So the main question of the research arises, “What kind of regulatory & support instruments are needed to promote effective participation of stakeholders in energy neutral housing

¹ Groningen energy neutral? A scenario study, TU Delft.
Energy neutral housing developments

developments and what role should municipality play to promote collaboration among stakeholders and realize energy neutral housing developments?"

METHODOLOGY
The following research methodology (figure I) was followed step by step to find the answer for the question. This research mainly consisted of Data collection, Survey and scenario analysis.

Data collection
Desk research is conducted to collect the data & information on the Danish regulatory & support instruments focussed on improving the energy efficiency of households and promoting renewable energy usage in housing sector. The Danish municipalities have played a proactive participatory role in the planning, implementation and realization phases of the projects. UK on the other hand has employed numerous financial support instruments to promote carbon reduction using microgeneration technology and decentralized energy sources. Hence from the desk research the instruments regulating & supporting energy efficiency measures, carbon reduction measure, usage of renewable energy and financial incentives are found out.

Data analysis
The data collected is analyzed to relate it to the Eindhoven scenario. Initially a survey is conducted to find the instruments prioritized & preferred by the local stakeholder groups and then a scenario analysis is conducted on Blixembosch Noord Oost development to validate the fact that the role of municipalities found from research can be employed played by municipality for successfully promoting stakeholders in energy neutral housing developments.

Figure I: Research overview

Survey
A survey questionnaire is designed to find the weights of the instruments found from research using pairwise comparison approach of Analytical Hierarchy Process. Pairwise comparisons are used to determine the relative importance of each alternative in terms of each criterion. 25 responses were obtained from the 50 sent to stakeholder groups of Municipality, Project developers, Energy consultants & consumers. The prioritized
Energy neutral housing developments

instruments based on all 25 stakeholder responses are found out along with the preferred instruments of each individual stakeholder groups.

**Scenario analysis**

To find the effect of the varying preferences of stakeholder groups and the role played by Eindhoven municipality on a practical energy neutral housing development scenario analysis is conducted. This analysis is used to explain the effect of varying preferences of different stakeholder groups found from the survey and the role adopted by Eindhoven municipality when implemented in reality. Scenarios are reflected on Blixembosch Noord Oost energy neutral housing development using Global scenario analysis.

**CONCLUSIONS**

The research shows the most important instruments required (figure II) for promoting stakeholder participation in Eindhoven’s energy neutral housing developments. Instruments need to be implemented to regulate energy efficiency of households and at the same time financial incentives focussed on promoting renewable energy generation in new households are required. Community owned cooperatives are found important for decentralized renewable energy generation. A participatory role is required to be played by Eindhoven municipality in different phases of project to promote effective collaboration between stakeholders and ensure their participation in energy neutral housing developments.

**Figure II:** Role required to be played by Eindhoven Municipality
DISCUSSION

The research considers the preferences of stakeholders as the only criteria to evaluate the instruments required for Eindhoven scenario. More studies to evaluate these instruments in terms of legal, financial and technical feasibilities are needed to be carried out. The instruments found from Denmark & UK experiences are adopted for only energy efficient and carbon neutral housing developments. This research presumes that a combination of these instruments will equally promote the energy neutral developments. This can lead to conflicting views, but in my perspective it is valid since the energy efficiency and carbon neutral are integral features of energy neutral housing concept. Therefore the developments in these fields will indirectly influence energy neutral developments.
ACKNOWLEDGEMENT

The vision and unwavering encouragement shown by my supervisor and mentor, Prof. Dr. ir. Bauke de Vries has been an invaluable contribution to this research study. He has been an excellent critic for my ideas which helped me hone my reasoning skills. I would like to acknowledge my assistant supervisor Dr. Qi Han for her diligence, support and friendly advice throughout this graduation period.

I express my limitless gratitude to Prof. dr. Ir. Wim Schaefer for providing this wonderful opportunity to work on a futuristic ambitious graduation theme. A special thanks to all the sponsors of this graduation studio. This study would not have been possible without the support and the creative environment facilitated by TU/e.

Words fall short in conveying my thankfulness towards my family for the affectionate moral support they have shown me over the years. Hi fives to all my friends for their suggestions, support and entertainment over these past six months.

I owe Google a big one since the background research focussed on Eindhoven would have not been possible with their magic tool, the Google Translator.
This thesis is dedicated to my late Grandmother who has inspired me with her hard fought life.
Energy neutral housing developments

4.2.2 Renewable Energy & technology ................................................................. 29
4.2.3 Financial support .................................................................................. 29
4.3 United Kingdom ....................................................................................... 31
4.3.1 Carbon reduction: ............................................................................... 31
4.3.2 Renewable energy & Technology ......................................................... 32
4.3.3 Financial support ............................................................................... 33
4.4 Role of Danish Municipalities .................................................................... 34
4.5 Conclusions ............................................................................................ 37

5 SURVEY ............................................................................................................ 41
5.1 Introduction ............................................................................................... 41
5.2 Analytical Hierarchy Process .................................................................... 41
5.3 Questionnaire Design & Respondents ...................................................... 43
5.4 Analysis & Results ................................................................................... 45
5.4.1 Priority Weights of Criteria .................................................................... 46
5.4.2 Priority weights of Individual stakeholder groups .................................. 47
5.5 Conclusion ............................................................................................... 49

6 SCENARIO ANALYSIS .................................................................................... 51
6.1 Introduction ............................................................................................... 51
6.2 Blixembosch Noord Oost energy neutral housing development ............. 51
6.3 Scenario Development ............................................................................ 52
6.3.1 Present role ........................................................................................... 53
6.3.2 Participatory scenario .......................................................................... 55
6.4 Conclusions ............................................................................................... 58

7. CONCLUSIONS .............................................................................................. 59
7.1 Introduction ............................................................................................... 59
7.2 Research answers .................................................................................... 59

8. RECOMMENDATIONS & DISCUSSION ...................................................... 65
8.1 Recommendations ................................................................................... 65
8.2 Discussion .................................................................................................. 66

BIBLIOGRAPHY ................................................................................................. 67

APPENDIX
ARTICLE
1. RESEARCH FRAMEWORK

1.1 Introduction
This chapter gives an overview of the research problem, research process followed and the research methods employed in this research. The main research questions which are answered through this research study are also stated.

1.2 Research Context
European Union has set energy targets for the member states for the year 2020 to reduce the green house gases, increase use of renewable energy sources and improve the energy efficiency in all sectors. With the energy demand of the 160 million buildings accounting for over 40% of annual energy consumption in the EU, the building sector offers the largest single potential for achieving these energy ambitions of the European Union set for 2020. Further, the households represent 63% of total energy consumption of the buildings sector. Households are also responsible for 13% of total green house gas emissions in the EU.

In view of the targets set by EU, the member states have set their own national targets in housing/building sector for the year 2020 and divided the tasks over National, regional and local levels. (C.A. Balaras et al, 2004). At the local level the municipalities have large potential to promote energy efficient housing developments through municipal planning practices and also have proven great interest in doing so. In the same context Eindhoven municipality has expressed its vision to go energy neutral in the built environment, specially housing sector, by 2020. Proven technology to realize energy neutral housing developments is available, but however practical realization of energy efficient housing developments has not been achieved yet.

Practical realization of energy efficient housing developments requires a transition in existing systems and ways of doing in the building sector. This is currently not happening in the building sector due to a deadlock in supply and demand. The construction companies do not offer developers to build energy efficient buildings as they cannot identify sufficient demand from consumers and thus developers complain about the reluctance of construction companies to come up with viable solutions (Rohracher 1991). Thus energy efficient buildings have not gained acceptance on the main-stream market. The current inertia is caused by a number of different factors that withhold existing building practices. But these factors are only to a small extent technical, since mature energy efficient technologies have been developed.

1.3 Need for Research
Lack of acceptance for energy efficient homes or buildings in the market is attributed to lack of strict regulations and appropriate forms of support for the stakeholders involved in housing sector & the end use customers. Lack of structured process and organized role to be followed by the municipality in the planning, development and realization phases has further lead to poor collaboration & communication between various stakeholders. This has lead to failure of realizing energy neutral housing developments and thus curbed the progress towards energy neutral ambitions of Eindhoven. There is a need for municipality to
promote energy neutral ambitions in housing sector through local means. This implies that
greater attention is needed towards supporting and encouraging a new role for municipality
in planning and regulating practices. So a key question arises, what kind of regulatory &
support instruments are needed to regulate the interests of stakeholders towards energy
neutral housing developments and what role should municipality play to promote
collaboration among stakeholders and realize energy neutral housing developments?
The first energy neutral project “Blixembosch Noord Oost” is still under development in
Eindhoven. Thus energy neutral housing developments are still new to the Dutch housing
sector and the municipality is looking for the right examples, which are actively taking place
as the latest developments and also proven in practice. Past research shows that Denmark
& UK have successfully promoted energy ambitions in their housing sectors by realizing
energy efficient and carbon neutral homes. So it is interesting to research on how the
successful experiences of Denmark & UK can be reflected on Eindhoven scenario.
From the problem the main question for this research can be defined as following “What
are the successful regulatory & support instruments required to foster the energy neutral
housing ambitions of Eindhoven and what is the role required to be played by Eindhoven
municipalities to promote successful participation of stakeholders in energy efficient housing
developments?” To find the answer to this main research question, the following questions
have been raised and answered through the course of research.

1.4 Framework of Questions
To understand the research scope and the main research question, it is important to answer
the various concepts related to this research question. To give the reader an overview of the
information present in the report the following sets of questions are framed which whose
answers can be found in the research.

- **Conceptual questions**: These questions are answered to provide the background
  information required to understand the need for this research

  1. What is the European Union’s energy vision for 2020?
  2. Why are member states concentrating on the housing sector?
  3. What is the energy ambition of Eindhoven municipality?
  4. What are energy neutral housing developments?
  5. What are the main features and who are the stakeholders involved in energy
     neutral housing developments?
  6. What are the regulatory & support instruments?
  7. What are the problems faced by municipalities in relation to energy neutral
     housing developments?

- **Sub questions of research**: Once the concept questions are answered, the questions
directed towards answering the main question are answered step wise. These
questions are framed below.
1 What are the successful instruments needed to foster energy neutral housing developments in Eindhoven?
1.1 What are the regulatory & support instruments employed in Denmark & UK?
1.2 How are the instruments found from UK & Denmark prioritized for Eindhoven scenario?
1.3 How can these instruments be adopted for Eindhoven scenario

2 What is the role of Eindhoven municipality to realize the energy neutral ambitions in Housing sector?
2.1 What is the role played by Danish municipalities in successfully realizing energy efficient housing developments?
2.2 What role is needed to be played by the municipality to promote stakeholder participation in the various phases of energy neutral housing developments?

3 How can the findings be validated for Blixembosch Noord Oost energy neutral developments?
3.1 What instruments can be implemented to ensure consumers to invest in energy neutral measures for achieving Blixembosch energy neutral housing development?

1.5 Research Model

Figure 1: An overview of the research work.

- **Literature review:** Background information and literature review required for the research was collected from scientific journals, Documents on climate & energy policies and relevant internet websites.
- **Data collection:** Successful regulation & support Instruments employed in Denmark & UK to promote the energy ambitions in housing sector are collected through a desk research. The More extensive information was collected through a study visit to Danish municipalities and the role played by Danish Municipalities in promoting stakeholder participation in energy efficient housing is found out.
- **Data analysis:** The instruments collected from these countries are prioritized for Eindhoven scenario by conducting an Internet- Based survey with relevant stakeholder
groups. From the results of the survey the individual preferences of instruments for each stakeholder group were analyzed using Analytical Hierarchy Process.

- **Scenario analysis**: To find the effect of the varying preferences of stakeholder groups and the role played by Eindhoven municipality on a practical energy neutral housing development scenario analysis is conducted. This analysis is used to explain the effect of varying preferences of different stakeholder groups found from the survey and the role adopted by Eindhoven municipality when implemented in reality

- **Conclusions**: The instruments that can be adopted / improved for Eindhoven scenario are discussed. The role required to be played by Eindhoven municipality is discussed with respect to the findings from research and scenario analysis. Further some recommendations for Blixembosch Noord Oost development are also presented.

1.6 **Research Methodologies**

Different research methods used for this research are briefly discussed. Most common research methods like Desk research, case studies, scenario analysis and mathematical methods are used in this research. Desk research to find the successful instruments employed in UK & Denmark was carried out through the internet websites, video files of best practices and scientific journals and site visits. Case studies are also used to describe the unique approaches followed in the Denmark & UK. Decision support models like Analytical Hierarchy process (AHP) using pairwise comparison is used to find the prioritized instruments for Eindhoven scenario. Finally scenario analysis was used to analyze the required role to be played by Eindhoven Municipality to promote its energy neutral housing developments.
2. ENERGY AMBITIONS IN HOUSING SECTOR

2.1 Introduction
This chapter gives a brief overview of the European Union’s policies on energy efficiency, renewable energy and carbon emission targets set for year 2020. This chapter discusses the energy ambitions set by the member states and the reason why member states have chosen housing sector to promote their energy ambitions. Further the roles of municipalities at the local level in achieving the housing energy targets and the energy ambitions of Eindhoven municipality are also presented.

2.2 European Union vision 2020
The European Union, under the Kyoto protocol, has set ambitious targets for greenhouse gas emissions reduction in order to limit the rising global temperature. At the same time, the EU has adopted equally ambitious targets for its future energy supply. It aims to meet these targets through a range of policy instruments at the Union, Member State and even sub national level. (Christoph Böhringer et al, 2009). The primary EU’s targets are:
- By 2020 Greenhouse gas emissions should be reduced by 20% with reference to 1990.
- 20% penetration of renewable energy by 2020.
- Improve energy efficiency by at least 20% between 2005 and 2020

In order to reach these targets the European Union (EU) Member States are working intensively to improve energy efficiency in all end-use sectors. They have increased the exploitation of renewable energy sources in order to reduce the dependency on fossil fuels and promote support self-sufficiency to achieve energy security. Energy efficiency is expected to play a key role in meeting the EU target in accordance to the Kyoto commitments to reduce CO2 emissions in an economic way (C.A. Balaras et al., 2004). Studies have shown that more than one-fifth of the present energy consumption and up to 30-45 million tones of CO2 per annum could be saved by 2010 by applying more ambitious standards to refurbishments and new building projects. At the end of 2006, the EU pledged to cut its annual consumption of primary energy by 20% by 2020. (Energy efficiency, 2006)

2.3 European Union Policies
To foster the speed of developments to reach the 2020 targets EU has adopted certain policies and legislations aimed at promoting the energy targets set on Carbon emissions, energy efficiency and renewable energy sources.

Renewable energy and Green house emissions
The European Union (EU) accounts for only 6.4% of the world’s use of RES. Despite this low figure, however, EU is a world leader in terms of energy technology. The reason for this is that the strong EU policy contained in the recent papers by the European Commission, such as the White Paper for a Community Strategy and Action Plan for RES and the Green Paper towards a European strategy for the security of energy supply. (K.D. Patlitzianas et al, 2005) The European Commission published a White Paper in 1997 setting out a Community strategy for achieving a 12% share of renewables in the EU’s energy mix. The decision was motivated by concerns about security of supply and environmental protection. The 12%
target was adopted in a 2001 directive on the promotion of electricity from renewable energy sources, which also included a 22.1% target for electricity for the EU-15. In 2001, the European Union’s Renewables Directive set a goal of providing 20% of the European Community’s electricity consumption from renewable energy by the year 2010. Member states are required to encourage renewable energy development and publish national targets, which are updated every 5 years (European Parliament and Council Directive, 2001). The legislation was an important part of the EU's measures to deliver on commitments made under the Kyoto Protocol. In January 2007, the Commission published a Renewable Energy Roadmap outlining a long-term strategy which called for a mandatory target of a 20% share of renewable energies in the EU’s energy mix by 2020. The target was endorsed by EU leaders in March 2007 (EU Renewable policy, 2007). To achieve this target EU adopted a new Renewables Directive in April 2009, called the 20-20 by 2020 package. This includes proposals for reducing the EU’s greenhouse gas emissions by 20% and increasing its proportion of final energy consumption from renewable sources to 20%. Both of these targets are to be achieved by 2020. In order to meet the EU renewable energy target each Member State are given a national target to meet based on their existing renewable generation, their GDP and a flat-rate increase for all (EU commission, 2008).

A range of policies has been developed and implemented at European level to promote the use of renewable energy (RE). These include pricing laws, quota requirements, production incentives, tax credits and trading systems out of which the feed-in tariff (FIT) and the renewable portfolio standard (RPS) or Renewable Obligation (RO) have been prominent. However the EU has not proposed an EU wide framework on support mechanisms because of the differing markets and local energy targets of the member states. Under the European renewable directive of 2009 support policies are a national prerogative. But European Commission published a report in 2005 assessing the support mechanisms that different member states have deployed for electricity from renewable sources.

**Energy efficiency**

Europe has conveyed its ambitious plan to cut its energy consumption by 20% by 2020 in a bid to reduce its dependency on imported oil and gas and slash its energy bill by an estimated 100 billion euro every year. If successful, the plan would also prevent 780 million tonnes of CO2 from being emitted in the atmosphere, or twice the amount the EU agreed to under the Kyoto Protocol. The European Union (EU) has adopted a framework for energy end-use efficiency and energy services. Among other things, this includes an indicative energy savings target for the Member States, obligations on national public authorities as regards energy savings and energy efficient procurement, and measures to promote energy efficiency and energy services. The EU has passed a number of directives to improve energy efficiency in member states. (EC, Energy efficiency)

The European Commission has committed Member States to address the issue of energy inefficiency of buildings. To reduce the energy inefficiency of buildings means that less energy should be used, while enjoying the same quality of life. This implies, among other things, raising the energy standards of mainstream buildings in order to reduce heat loss from building envelopes and implementing a greater share of renewable energy in buildings. In order to promote energy efficient buildings and compensate for inadequacies of the market, the Commission especially highlights that public authorities, at the European and
national level, need to set up appropriate frameworks (European Commission, 2006). In context to the housing/building sectors the directives which are focused on reducing the energy consumption of households with respect to the quality of construction, renovation, using efficient electrical appliances and reducing electricity consumption by levying energy taxes. The Directive on energy performance of buildings, Directives on the labelling of household energy appliances, Directive on the taxation of energy products and electricity are some of the directives focussed on energy efficiency in households (EU 2020 Vision, 2007)

2.4 Energy in the Housing sector

In European Union buildings account for 40 % of the energy demand and about one thirds of green house gases of which about two-thirds are attributed to residential and one-third to commercial buildings (EC Green paper, 2000). With the energy demand of the 160 million buildings accounting for over 40% of annual energy consumption in the EU, the building sector offers the largest single potential for energy efficiency in the EU. Further, the households represent 63% of total energy consumption of the buildings sector. So, an increase of building energy performance can constitute an important instrument in the efforts to reduce the EU energy import dependency (currently at about 48%) and comply with the Kyoto Protocol to reduce carbon dioxide emissions. (C.A. Balaras et al., 2007)

The households represent 63% of total energy consumption of the buildings sector. In 2005, the final electricity consumption totaled 2756 TWh in EU-27 of which 799 TWh$^2$ was attributed to the households which proportionate to 29% of total consumption. Electricity consumption in the household sector has grown by 12.5% from 2000. The gross domestic product of EU-27 has increased by 8.5% from 2000 to 2005. Hence, energy demand in the household sector has been growing faster than GDP which is not due to the population growth which was 1.8% over the same period. In addition to the development of economy and population, other important factors in the development of household energy consumption are the number of households, the evolvement of floor space and the increasing range of energy consuming products (Eurostat, 2007). Thus the energy consumption by end-use in EU-27 member states is dominated by space heating (77%), followed by water heating (11%) and electrical appliances and lighting with 11%. Energy usage is lowest for cooking (3%). (Enerdata, 2007)

In 2000 approximately 17% of the total CO2 emissions were generated from the residential and tertiary sector without taking into account the CO2 emissions associated with electricity consumption in buildings (Misragedis et al., 2004) Carbon dioxide is the most important greenhouse gas and accounted for 82% of total EU emissions in 2002. 39% of the total EU CO2 emissions originate from electricity and heat production. In addition to this, CO2 emissions from residential buildings account for 10% and emissions from commercial buildings account for 3.7% of the total GHG emissions (Source:EEA,2004). Therefore, buildings constitute an important sector in the effort to reduce environmental emissions. On the other hand the environmental building emissions are related to the energy consumption during operation and to the use of materials during construction and throughout their lifetime as a result of renovation and refurbishment, or even demolition.

$^2$ Tetra Watt-hour=10$^4$12 watt hours
The EPPA reference projection shows that housing sector will be the highest CO2 emitting sector with 27% of total emissions by 2020 (Laurent L. Viguier et al, 2001). Further households energy demand is expected to increase by 0.6% per annum between 2000 and 2030. This is attributed to the growing number of households, around 40 million, in this time period. Given the long lifetime of buildings (50 to more than 100 years) and the high number of the already existing buildings, it is clear that there is a large potential for improving the energy performance of buildings in the short and medium term. This can also have a strong impact on the efforts to reduce greenhouse gas emissions in accordance to the Kyoto protocol and the ratified commitments by most EU member states (C.A. Balaras et al., 2007).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Households (residential)</td>
<td>260</td>
<td>338</td>
<td>91</td>
<td>27</td>
</tr>
<tr>
<td>Commercial buildings</td>
<td>157</td>
<td>211</td>
<td>63</td>
<td>30</td>
</tr>
<tr>
<td>Transport</td>
<td>322</td>
<td>405</td>
<td>105</td>
<td>26</td>
</tr>
<tr>
<td>Manufacturing industry</td>
<td>267</td>
<td>382</td>
<td>95</td>
<td>25</td>
</tr>
</tbody>
</table>

Figure 2: Estimated energy saving potential in end use sectors (EU 2020 Vision, 2007)

2.5 Energy ambitions of the Member states

The EU-policies favored a flexible approach, requiring member states to lay down concrete requirements to achieve their targets in housing sector, while accounting for local climate conditions and building traditions. As a result, policies to regulate and promote energy efficiency, carbon emission reduction and use of renewable energy sources in housing sector have been developed across Europe, using instruments ranging from mandatory norms to guidelines that can be applied voluntarily. Member states, as per the EU regulations on Carbon emissions, renewable energy sources and energy efficiency, have outlined their own energy ambitions for year 2020 and set them as national level targets. The ambitions of the leading EU-15 member states are shown in table 1.

The UK government has set target for achieving zero-carbon homes by 2016. To achieve this target UK has adopted an approach aimed at increasing energy efficiency of homes fuelled by decentralized energy systems (Miliband, 2006). On the other hand Denmark has energy ambitions to reduce 75% of energy usage in building sector and also reduce 20% of green house emissions by 2020. Denmark has also spurred renewable energy development by establishing feed-in tariffs and modernizing the electric grid. Currently renewable resources supply 17 percent of Denmark’s total energy and the government plans to reach 30 percent by 2030. By 2012 France aims that all new buildings to be energy positive, i.e. produce more energy than they consume. The Netherlands in its climate policy plan of 2007 set the target to build zero energy/ energy neutral houses and buildings in 2020.

The UK government has introduced new housing growth programmes to develop 2 million new homes by 2016 to provide a test bed for zero carbon technologies and drive changes in house-building sector to deliver zero carbon homes from 2016. Considering the level of change required and short frame of time, UK has adopted a series of instruments like
Energy neutral housing developments

regulations and financial incentives to drive a change in existing housing industry, public awareness and attitudes (Williams, J. 2009). Similarly Denmark the most energy efficient country in the EU has achieved impressive gains in energy efficiency of housing sector through strict building standards, a labeling system for energy-efficient appliances, public awareness campaigns, requirement of energy certificates for sale of houses, and other residential efficiency regulations and support instruments. Thus the member states have announced their plans for improving energy requirements in buildings and households and have set targets for new energy requirement up to year 2020. But in their long term objective their main aim is to provide valuable guidelines for the construction sector to prepare for the further development and implementation of the strategy (EuroACE and Sbi, 2008).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>-25%</td>
<td></td>
<td></td>
<td></td>
<td>-50%</td>
<td>-75%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td></td>
<td>50kwh/m²</td>
<td></td>
<td></td>
<td></td>
<td>Positive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>-30%</td>
<td>-49%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hungary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0-fossil fuels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>-25%</td>
<td></td>
<td></td>
<td>-50%</td>
<td>PH Level*</td>
<td>0-energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>-25%</td>
<td>-44% PH Level</td>
<td></td>
<td></td>
<td>Carbon Neutral</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Member states energy ambitions in Building sector. PH*-Passive haus. (Adopted from EuroACE and Sbi, 2008).

2.6 Role of Municipalities

The energy ambitions are usually spread over three layers of governance as observed in EU member states namely the Central government, Regional government and Local government (municipality). Broadly speaking, the national government is responsible for market creation and support, infrastructure provision, promoting technology development and setting broad guidelines for land use and energy. The local government or the municipality is where energy projects are implemented and take root. They operate under national and regional guidance. The regional government usually transfers the experiences between central and local governments. For example the multilevel governance and the stakeholder involved in renewable energy sector in UK is shown below (Adrian Smith, 2007). For example, the multi level governance involved in UK is shown in figure 3.

Although centralized regulation schemes have played an important part of promoting energy efficient buildings, the role of municipalities is growing stronger. In relation to sustainable development municipalities have been widely recognized as leaders of local
Energy neutral housing developments

initiatives (United Nations, 1992). Through performance of Local Agenda 21 activities, municipalities have gained a stronger recognition (and more experience) as local agents of change in terms of promoting sustainable development. Their activities in member states have proven that municipalities represent an important planning authority to promote the ambitions of sustainable development at the local level.

![Diagram showing multi-level governance of renewable energy in UK](Adopted from Adrian Smith, 2007)

The municipalities play an important role in the planning and regulation of built environment as the European spatial planning system outlays certain building performance responsibilities to be fulfilled at the local level. As a result, municipalities act as liaisons between the political energy efficiency strategies at the international and national level, and practitioners in the building sector at the local level (DTU, 2009). Similarly the emphasis in the Dutch planning system is on the local land allocation plan. This is the only plan with direct legal consequences for private building initiatives. The private builder’s development plans are obligated to satisfy the local land allocation plan of the municipality. If the plans fail to comply with the land allocation plan then the municipality can refuse the builder’s development plans. Land allocation plans are obligatory for rural areas and optional for urban land. Failure to comply with the land allocation plan is punishable. Land allocation plans are the basis for municipalities’ right of expropriation. The adoption and revision of valid land allocation plans for the built-up area of municipalities is problematic. Few municipalities are successful in reviewing plans in time. Revision is legally required every 10 years. The spatial local planning system existing in Netherlands is shown in figure 4 (A. van der Valk, 2002).

Thus the potentiality of municipalities to promote energy efficient buildings through municipal planning practices is large, since municipalities typically have a powerful local planning role in terms of developing local urban areas and authorizing local building projects. Besides having the authority to promote energy efficiency at the local level,
municipalities also prove to have interests in doing so. To complement these interests there is a need for strict national level and local policies which are aimed at regulating and supporting this transition in housing sector. For example the Danish and UK municipalities have combined strict regulations enforcing energy targets to be achieved in the housing industry with support instruments to help the relevant stakeholders achieve these targets.

<table>
<thead>
<tr>
<th>Tiers of government</th>
<th>Legal spatial plan</th>
<th>Area</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central government</td>
<td>Planning core decision</td>
<td>All of the country</td>
<td>Broad national policy guidelines</td>
</tr>
<tr>
<td>Provinces (12)</td>
<td>Regional structure plan</td>
<td>Province or part of a province</td>
<td>An overview of provincial planning policy</td>
</tr>
<tr>
<td>Municipalities (500)</td>
<td>Local structure plan</td>
<td>Municipality or combination of municipalities</td>
<td>Municipal policy guidelines</td>
</tr>
<tr>
<td></td>
<td>Land allocation plan</td>
<td>Part of a municipality</td>
<td>Binding maps and regulations</td>
</tr>
</tbody>
</table>

Figure 4: Netherlands planning system at different tiers. (Adopted from A. van der Valk, 2002)

### 2.7 Eindhoven’s vision 2020

In its vision “Milieuvisie 2030” Eindhoven municipality has indicated that it will make substantial contribution towards the national climate targets set in response to the Kyoto climate conference. The environmental vision is based on energy savings and increasing the generation of sustainable energy in the city. In the coalition agreement 2006-2010 “Sustainability and climate”, the planning and implementation of energy savings has been listed as one of the spear heads (Eindhoven, 2009).

Eindhoven’s city council has recently ordered in the period between 2035 and 2045 it will be Energy neutral. The unique cooperation between Brainport⁴, municipalities, companies and knowledge institutions is an excellent base to provide substance to the energy-neutral ambition. The Brabant provincial government has the role of catalyst whereas the local municipalities provide energy-neutral construction projects with proper legislative and regulatory space to accommodate parties from business and the knowledge field. The knowledge and technique is available but there is a need to implement these techniques in a structured process. (Brainport).The timeline below shows the developments which have taken place so far and the future vision of the Eindhoven municipality in cooperation with “Triple Helix”.

Eindhoven has expressed its vision 2040 to become an energy-neutral in all sectors but the municipality aims to go energy neutral in the built environment, specially housing sector, by

---

⁴ Brainport – a hot spot in the high technology region of south-eastern Netherlands is the hub of a network of companies, knowledge centers and government. It is a unique area with intensive and innovative cooperation between organizations open to new idea.
Energy neutral housing developments

2020. By this it means that any form of energy used in the houses should be generated by renewable energy sources, there should be reduction in CO2 emissions and need for decentralized energy systems. Eindhoven set out its ambitions for sustainability in the programme “Duurzaamheid en Klimaatbeleid” aimed at achieving the sustainable ambitions in both new and existing housing construction. The goal is to reduce the energy consumption of all building-related construction by 25% by January 1, 2011 and 50% by January 1, 2015 (over 2007). Ultimately this should lead to energy-neutral building in 2020 (Gemeente Eindhoven, 2008).

![Image](image.png)

Figure 5: Eindhoven’s energy neutral vision 2035-43 and developments so far.

Eindhoven Municipality is working on its energy road map for achieving its energy ambitions set for 2035-45. Energy conservation and renewable energy generation have been set as the main targets in the road map. These are also the first two steps of widely accepted “Trias Energetica” model for sustainable development. It has planned to extend this model further to offset carbon emissions and thus achieve energy neutrality with a combination of Energy efficiency, Renewable energy generation and carbon reduction. It is a long term vision and to ensure this in the short term Eindhoven has decided to start building energy neutral residential areas and it aims to become energy neutral in built environment by 2020. These housing developments after they are built will determine the feasibility of an energy-neutral region for future. One such community being developed in Eindhoven now is “Blixembosch Noord Oost energy neutral housing development”.

### 2.7.1 Need for Energy neutral housing in Eindhoven

As of 2006, in building sector including municipal buildings, homes, businesses, public lighting, etc within the city of Eindhoven consumes 1.1 billion kWh of electricity and 279 million m3 of natural gas (NRE netwerk). The share of renewable energy was nil. In the coming years 1500 new houses will be constructed every year. Also with around 100.000 existing homes in Eindhoven, the housing sector has the largest share in Eindhoven’s total energy consumption. An average household consumes 3500 kWh of electricity and 1740 m3 of gas per dwelling and total CO2 emissions of 475.000 tonnes in a year (Gemeente Eindhoven, 2008). This shows that there is a huge scope for reducing energy consumption in the housing sector and the need for remaining energy to be supplied by using renewable sources.
Energy neutral housing developments

Energy neutral homes have proven to benefit residents of lower energy costs, with even better quality and comfort of home (IEEE spectrum, 2010). Despite the advantages of energy saving measures for the house owners/ consumers, the steps taken so far have not been successful in promoting them. The Eindhoven municipality however is making efforts to promote energy neutral concepts among the residents with sufficient knowledge and investment resources. in the coming years a large number new housing developments will be developed in Eindhoven i.e. around 1500 new homes per year and by opting for innovative energy and infrastructure installations energy neutral homes with high comfort can be achieved. The life of a house is long and for that reason the energy supply of dwellings also requires adequate attention. Achieving energy neutral homes is technically very possible and research for the development of Blixembosch Noord Oost has shown that this is also financially feasible (Petra rovers’ et al. 2009). However the role of the municipality and the redesign of development and construction process are still needed to actually achieve the realization of energy neutral homes.

The Blixembosch Noord Oost development is the first large scale energy neutral housing development planned for Eindhoven. The feasibility of its realization will decide the possibilities for future energy neutral housing developments. Currently it is still in its planning stages and is already well behind the planned realization time due to certain problems faced by the promoters. Therefore there is a need for municipality to successfully promote this project, to achieve a benchmark in energy neutral housing developments. Thus the findings of this research are aimed to throw some light into the way how the implementation and realization of this project should be carried out.

2.8 Conclusions

- With the EU obligations to improve energy efficiency, reduce carbon emissions and produce renewable energy, member states have set energy ambitions for year 2020 concentrated mainly on the housing sector due to its scope for potential savings.
- The National energy ambitions are divided into three layers of governance and at the local level Municipalities have shown interest to promote energy ambitions in housing sector at the.
- Eindhoven has set energy ambitions to go develop energy neutral houses by 2020 and it has decided to build energy neutral housing areas to determine the feasibility of energy neutral region for future.
- Realizing energy neutral houses has been proved to be financially feasible. The role of the municipality in the redesign of development and construction process is still needed to actually achieve the realization of energy neutral homes.
- Blixembosch Noord Oost energy neutral housing development is one such development which is still in the planning stage and the promoters are currently facing certain problems. There is a need promote a vision for the municipality to successfully realize this project since it is the pioneering project of its kind in Eindhoven.

---

5 Hurks Presentation: Gemeente Eindhoven Ambitie 2040, ENERGIENEUTRAAL WONEN IN BRAINPORT
Energy neutral housing developments
3 ENERGY NEUTRAL HOUSING DEVELOPMENTS

3.1 Introduction
This chapter describes the literature on the concept & features of energy neutral housing developments and the stakeholders involved in them. Further the Dutch policies promoting energy developments and the problems faced by Eindhoven municipality are also discussed.

3.2 Energy neutral housing developments
In literature there exist many definitions for Energy neutral houses which are also known as Zero energy homes in some literature. But for the scope of this research the Energy neutral/Zero energy home definition has been taken from ECEEE. It defines it as “The overall annual primary energy consumption is equal to or less than the energy production from renewable energy sources on site as a result of the very high level of energy efficiency of the house”. It means the total net energy consumption in the household over a year is zero or more than zero where the energy is generated from decentralized renewable energy sources. This is defined under a condition that the house has high energy efficiency. Thus an energy-neutral variant aims at a higher level of ambition for technical implementation of the district, combined with sustained production of all necessary electricity.

An energy-neutral housing community is defined as a residential area where the net total energy used in all housing related processes and activities is generated within the district or community using renewable energy sources. These activities include heating, ventilation and possibly cooling of the housing, warm water, cooking, all electricity used in house. In order to achieve this must in all cases involve a combination of energy saving techniques and behavior and sustainable generation of electricity (Bauke de Vries, 2008). In such neighborhoods there is no net input of fossil fuels, by a combination of energy saving in housing, sustainable collective systems for heat and / or cooling and sustainable generation of electricity in or near the district. This corresponds to an Energy Performance on Location (EPL) of 10. But by meeting the current building regulations & requirements an EPL of only 6 is achieved (Bauke de Vries, 2008).

3.2.1 Features of energy neutral housing developments: An Energy neutral home (ZEH) has to have highly energy efficient to reduce the energy consumption per sq meter. To achieve this they usually feature high levels of insulation and air sealing; windows with energy properties selected for the climate, well designed and installation of HVAC and plumbing systems to minimize energy loss, high efficiency HVAC equipment, high efficiency lights and appliances. In addition to this the energy supplied to the energy neutral homes should also be completely generated on site using non carbon emitting renewable sources. Combination of microgeneration and Decentralized renewable energy technologies like solar PV, solar heaters, Heat pumps, Windmills etc is employed to provide energy to an energy neutral house (NAHB, 2006). Decentralized or distributed energy supply refers to the generation of energy close to the point of use. It can denote a range of generator sizes from community or district-level down to individual households. Microgeneration implies, the

---

6 ECEEE, European council for an energy efficient economy
small-scale production of heat and/or electricity (generation of a capacity of less than 50 kW) from a low- carbon source. The variety of technologies caught by this definition includes solar collectors, photovoltaic cells, micro-wind, micro-hydro, heat pumps etc.

At present, a significant proportion of green power sold in the Netherlands is produced from biomass. This has resulted in a net increase of CO2 emissions rather than a decrease (Bauke de Vries, 2008). For energy neutral houses it is an important requirement that the renewable sources used to generate heat or electrical energy should not release carbon emissions. Therefore for developing energy neutral housing developments, there is a need for alternative decentralized renewable energy sources.

3.2.2 Stakeholders & Development process: The most common definitions view project stakeholders broadly, as any group or individual who can affect or is affected by the project (Project Management Institute, 2004). Energy neutral developments are different from other construction projects because of the development process also includes the energy issues like e the efficient design of homes, generation of electricity within the community etc. In energy neutral/efficient housing developments the Local authorities (Municipalities) play an important role in promoting and facilitating the process. For employing energy neutral/efficient housing developments other parties or stakeholders like project developers, energy consultants and prospective owners/customers are also important (ENPIRE, 2009). In case of social housing there are also housing associations involved.

- **Municipality:** The municipalities have the task to contribute to the national energy targets by accomplishing the target goals of national energy policies. Thus they are obliged to promote energy neutral developments in their local plans and play a key role in the projects/process. The municipality has the task to create conditions, encourage and facilitate the participation of other stakeholder groups.

- **Project developer:** They are the private companies interested in getting an economical profit and positive market image. They are responsible to materialize the project, bearing in mind the costs related to dwellings (higher costs for improved comforts, housing quality, and decreased energy costs associated to their constructions). Project developers are directly involved in the process because they are responsible of the organization of the investments and they are responsible for the dwellings exploitation.

- **Energy consultant:** They are usually related to the municipality authorities and are responsible for promoting a reasonable use of energy in the local area. Energy consultants/ agencies play a significant role promoting the relations between the other involved parts and deciding different energy related issues.

- **End Customers:** Since the energy developments are new concepts the end users also become important stakeholders in terms of adopting energy neutral homes. The main issues where customers express their viewpoint are regard to quality conditions of dwellings and services, comfort degree, and about energy costs to support.

*Development process:* The project development any general housing developments is broadly divided into planning, implementation and realization phases. This process in relation to energy neutral developments can be described as follows.
Energy neutral housing developments

- **Planning phase**: This is the initial phase where the master plan for the development is drafted and sent for approval. This plan outlines the vision of stakeholders through design of rules & regulations, range of facilities, housing locations planned for energy neutral development.

- **Implementation phase**: In this phase the feasibility of master plan is checked. The master plan is to be approved by the stakeholders and the necessary requirements are checked for feasibility. For example selection of energy concept and its impact on housing design, quality of materials & technology required to achieve the epc levels in houses, expected costs and profits of the selected renewable energy concept etc.

- **Realization phase**: In this phase the energy technologies and houses are realized based on the finalized feasibility concepts from implementation phase. The houses are available for sale to the customers’ and the community is ready for people to live in.

Knowledge transfer, communication instruments play a key role in the development of energy neutral houses. The success of energy neutral housing developments is dependent on the successful collaboration and participation of these stakeholders in the different phases of project. Actor oriented knowledge is needed at specific stages of both building process, e.g. when the housing programme is set up, in resident participation processes, in building teams, and at controlled moments on the building site. Lack of past practical experience is affecting the decision process, and the adoption of energy efficiency measures by actors.

**3.2.3 Regulation & Support Instruments**: The municipalities have combined a number of policy instruments and approaches in their planning practices in order to cope with the challenge of mobilizing change among local stakeholders. Some of the applied instruments are based within traditional planning frameworks based on ideas of regulation and support, whereas other instruments represent more innovative methods of facilitation (CONCERTO, 2009). These instruments are divided into national level and local level instruments. In member states the national government proposes certain regulations for example Building codes, Feed in tariffs, Renewable obligations which are employed at the local levels. At the same time even municipalities or regional governments can set their own instruments for example building regulations, subsidies etc. These regulating & support instruments for energy neutral developments are directed towards improving energy efficiency, reducing carbon emissions, producing renewable energy and providing financial / facilitation support. Each of these means entails different promoters and inhibitors in terms of the ability of municipalities to promote energy neutral housing developments.

- **Regulations (R)**: Regulation is the strongest singular means to ensure that specific improved energy requirements in households are complied with in practice. Certain requirements are made directly binding for developers, constructors, Energy companies, House owners and energy suppliers involved in the building sector through a specific law passed by national government or municipality in its local plans. Regulations are hence strong instruments to impose requirements to housing sector stakeholders. For example, building regulations, local spatial plans, obligations
on energy companies, easements etc are examples of regulations employed at national & local level.

- **Support (S):** An important means to promote implementation of improved energy developments in building sector is to support the transition process by minimizing barriers that impede changes. Support instruments are important since it involves some risks and losses to the stakeholders acting as prime movers. The idea is to compensate for the challenges involved in being prime mover and innovative to foster the transition process. Support is divided into two forms, facilitation and financial support.
  - Financial support involves in terms of providing economics subsidies in order to compensate for additional costs of investments made by the stakeholders.
  - Facilitation support relates to providing specific tools and guidelines in order to make the task easier for the initiator. Like information on technology, saving measures, Demonstration programmes etc. in order to support new competences and promote advantages of energy neutral/efficient homes. (DTU, 2009)

### 3.3 Shortcomings in Dutch policies

The Dutch government has introduced policies to help the local municipalities to promote the energy neutral concept among the housing & construction sector. The energy policy for the residential sector is characterized by a set of instruments targeted at various aspects of residential energy use. This package of regulation and support instruments aims to increase the awareness, to provide insight in self-regulations, to stimulate home owners to take measures to improve the efficiency of their houses and contains regulation for new houses. National building regulations like minimum epc requirements, energy labeling of buildings, energy taxes, etc and support instruments like Green funds, financial subsidies for energy efficient building material, renewable technology etc have been employed by the municipalities. Further to reduce barriers for investments in energy efficiency measures Meer met Minder programme was introduced where the government signed voluntary agreements with key players within the Dutch housing, energy and construction sec-tor (MURE database, 2008).

However Incentives for renewable energy sources (RES) like Source specific premium tariffs were introduced in 2003 but later stopped in 2006 due to budget constraints. An energy tax exemption for RES was in place until 1 January 2005 (EC, 2008). The current incentives available are less generous for the stakeholders. For example, Housing corporations investing in energy efficiency are offered effectively an 11% tax discount; households, which typically can obtain loans at 10% for energy-saving measures, are now offered loans at 9% interest. VAT reduction from 19% to 16% for insulation measures for only refurbishments. This has discouraged many producers and consumers to switch to renewable energy sources. Further failure to launch energy labeling for buildings at the right time (SWKI, Energyclaim.nl) and improper execution of EPC (Nyenrode University, 2010) have affected the progress and efforts of municipalities. As a result there is still a need for more improved, innovative and effective instruments that can implemented by the municipality at the local level.

The Dutch policy instruments have failed to instigate the adoption of energy efficiency and measures for energy neutral developments. Even the research by Beerepoot, 2007 shows
that a broad scale adoption of energy efficiency measures fails to occur in the existing Dutch housing sector, which has related to the lack of structural cooperation between different actors in the mainly project-based building sector. Therefore sustainable housing has been adapted slowly. These barriers at the policy and strategy level especially the perceived costs of implementing environmental management; the lack of market demand and the poor capture of benefits have been identified (Sunikka and Boon, 2002).

Modest incentives do not appear to have attracted sufficient consumer attention. The very modest financial incentives that the Dutch government has offered to date appear to have had little impact and explain why the Dutch Parliament is keen to move to either regulation or energy efficiency obligations. This lack of energy efficiency uptake when the financial incentives are modest is not unique to the Netherlands, and there is widespread evidence that with current public perception, significant financial incentives are needed to bring about large-scale activity in energy efficiency.

The research conducted by Hans, Ingmar, 2008 on Groningen’s CO2 neutral ambitions shows that serious investments and/or collaborations of all stakeholders is necessary for such projects to become practically feasible. Energy neutral homes/developments have not gained acceptance on the mainstream market due to lack of sufficient demand from the consumers and thus no promotion from private developers (Rohracher 1991). The current inertia is caused by a number of different factors that withhold existing building practices. These factors are only to a small extent technical, since mature energy efficient technologies have been developed. The European Commission estimates that it will take 10-15 years for the full accumulation of the necessary knowledge, training of relevant experts, such as architects, constructors, auditors, and availability of construction products and technologies (ECEEE, 2009).

3.4 Conclusions
The ambitions of Eindhoven municipality and literature review show that to realize energy neutral housing developments there is a need for strong regulatory & support instruments to promote transition in existing practices of housing sector. In the present situation the progress in energy neutral housing ambition of Eindhoven is being affected due to the following factors. (Jan Bekering, 2009)

- **Lack of strict regulations & appropriate support**: Enforcement regulations to enforce building and energy saving regulations in energy neutral housing developments is lacking in the current Dutch policies. Lack of efficient regulatory instruments to achieve energy conservation, carbon reduction and higher usage of renewable energy in new housing developments surpassing national standards is also a problem. The Dutch municipalities through experience have claimed for the need of stable, long-term oriented financial rewarding support systems for investing in large energy transition projects, which cannot be sufficiently covered by the current temporary, discontinuous and experimental character of financial incentives.

- **Lack of structured collaboration & knowledge among stakeholders**: Lack of structural cooperation among building actors and lacking motivation to deviate from traditional construction processes and work habits, is considered a barrier to the energy transition of the Dutch housing stock (M.Tambach et al., 2010). This lack of cooperation is attributed to the varied interests of stakeholders. For example, the municipality aims to realize an energy neutral development to get self recognition at
national and international level. The project developers may target profits and image for their company, the consumers aim for comfortable and affordable houses with lower energy bills.

- **Lack of market demand:** One of the main challenges in terms of motivating relevant stakeholders to get involved in energy neutral project relates to the economy, since the building lots are less attractive for developers compared to other building lots because the initial developers tends to raise the costs, hence impeding the project compared to competing development areas. Thus these high costs of Energy neutral homes are barrier for customers. Builders are often skeptical of homeowner’s willingness to pay for advanced energy efficiency and renewable energy systems and thus not ready to take up such projects. The consumers are still not willing to invest high amounts in energy neutral concept and wait for long pay back periods. Therefore homeowners can only place value in energy neutral homes if they have a basic understanding of the concept. There is a need to develop energy neutral concept in relation to monetary benefits for end consumers.

### 3.4.1 Need to learn from European experiences

Platform Energie Transitie Gebouwde Omgeving (PeGO) has stated that there is a need for a new role to be played by interesting stakeholders to contribute to the developments process in view of overcoming the current problems. Further the need for changes in policies towards sustainability and monitoring of ongoing projects has been stated as important for improving development process of Energy neutral housing developments (SenterNovem, 2007). According to Lomas, K. J. (2010) reducing energy consumption and implementing energy efficient measures in housing sectors is challenging since there is a shortage of information tools for promoting policies effectively. Thus there is a need for that valuable new insight to be gained by collecting hard data, i.e. measurement, monitoring, questionnaires and surveys and by examining activities in other countries. The Eindhoven municipality now is aiming to actively cooperate with all actors and parties that can contribute to the Achieving the goal of energy neutrality between 2035 and 2045. The municipality is looking for the right examples, which are actively taking place as the latest developments and also proven in practice.

European member states of Denmark & UK have achieved progress in their local energy ambitions in housing sector. Denmark is considered the most energy efficient country in the EU due to its strict building codes, energy labeling programs, and other policy measures. Denmark has spurred renewable energy development in households by establishing long term feed in tariffs and community owned energy farms. Danish municipalities like Stenløse, Hillerød, Samso, Kolding etc have successfully accomplished energy efficient housing developments in the recent past. UK on the other hand has used support and facilitation instruments to encourage the installation of microgeneration technology in conjunction with energy efficient measures to achieve a real impact on reducing carbon emissions from housing sectors (A.S. Bahaj et al., 2007).

### 3.4.2 Research question

The failure to realize energy neutral developments is attributed to the lack of strict regulations & support instruments, lack of structured collaboration among stakeholders involved and lack of demand from the consumer side. There is a need to promote good
structured communication and support among the stakeholders involved to facilitate their participation in energy neutral housing developments. The local municipalities of Denmark and UK local councils have successfully promoted energy efficient and carbon neutral housing developments. Thus Eindhoven needs to learn, from the experiences of Denmark & UK municipalities to foster its energy neutral ambitions. This raises the main question for research,

“What are the successful regulatory & support instruments required to foster the energy neutral housing ambitions of Eindhoven and what is the role required to be played by Eindhoven municipalities to promote successful participation of stakeholders in energy efficient housing developments?”

1.1 What are the regulatory & support instruments employed in Denmark & UK?  
2.1 What is the role played by Danish municipalities in successfully realizing energy efficient housing developments
Energy neutral housing developments
4 LESSONS FROM DENMARK & UK

4.1 Introduction
This chapter discusses the regulation and support instruments implemented by Danish & UK municipalities to successfully promote Energy efficiency, Carbon emission reduction and use of renewable energy in the housing sectors. These instruments are divided into regulation and support instruments based on the scope of their implementation. Further the role played by Danish municipalities to promote effective participation of stakeholders in energy efficient housing projects is also discussed.

4.2 Denmark:
Strict building codes, energy labeling programs, and other policy measures. Denmark has spurred renewable energy development by establishing feed-in tariffs and modernizing the electric grid. Renewable resources supply 17 percent of Denmark’s total energy and the government plans to reach 30 percent by 2030. Renewable resources currently supply almost 30 percent of Denmark’s electricity, despite having no hydropower resources. Wind power is the largest source of renewable electricity, followed by biomass. Energy savings are widely recognized as one of the most important elements of Danish energy policy. The EU proposal of January 2008 regarding actions to limit climate change and the Danish Energy Agreement of February 2008 both emphasize energy savings. This may be seen as a continuation of the Danish energy savings policy that has taken place during the last 35 years (energyanalyse.dk). The Danish government’s target is that by 2020 all new buildings will use 75% less energy than new buildings constructed according to the current Building Regulations (Thomsen and Wittchen 2008). The driving regulatory and support instruments encouraging energy efficient housing developments are explained in the following paragraphs.

4.2.1 Energy efficiency: To promote energy efficient houses at the municipality level the main regulatory initiatives include stringent energy requirements included in the building code, Energy labeling of households and appliances, energy taxes and obligations for energy companies. To promote these regulations among the housing industry and households Danish municipalities have made use of innovative support systems like Energy saving trust, demonstration houses, collaboration with technology manufacturers and knowledge transfer. The municipalities like Hillerød, Samso, Stenløse, and Egedal have realized energy efficient housing developments using these instruments.

- **Strict Building code (R):** The energy requirements in the Danish Building Regulation are continuously tightened in order to assure lower consumption of energy. It has successfully introduced two new low energy building ratings, class 1 and 2 which require buildings consuming less than 50 % and 75% of the energy respectively required for new buildings. The energy class 2 has been set as a minimum requirement for 2010 and energy class 1 for 2015. This is helping the developers and builders to prepare their housing developments for future (Florida SEC, 2006). Denmark has planned to promote onsite energy generation through its upcoming building code for 2010. The building code also suggest that for low-energy buildings,
it is proposed not to connect to district heating and natural-gas systems as heat supply from district heating will not be economically profitable due to low energy consumption.

- **Energy labeling of buildings (R):** The building labeling scheme requires that energy certificates be issued when buildings change hands. This is made mandatory through strict building code regulations administered through the Denmark Energy Agency using certified inspectors. The Danish energy labels are not to inform about payback period but to provide house buyers with information on cost of investment and possible savings. (Source: Energy labels, EU)

- **Energy efficient obligations for Companies (R):** Initially the grid companies for electricity, natural gas, and district heating have been obliged to realize energy efficiency activities by providing advice, energy audits, subsidies etc to the consumers. From 2006 obligations with annual energy targets were introduced. The target for 2006-09 was set as 0.7% decrease in consumption in all sectors. This has been successfully realized and the target for 2012 has been set as 1.2%. The Danish power distribution companies, which are either consumer or publicly owned, have established extensive information and consultancy schemes recognized as a natural activity by the regulatory authorities. Most companies are involved in local information activities directed at consumers and educational institutions and offer a certain basic package of consultancy on electricity savings free of charge. (Helen O’Neill and Andrew Warren, 2001)

- **Easements (R):** Easements are used to provide the owner of land with some extensive property right. Such easements were applied by Danish municipalities in order to make energy performance requirements lawfully binding for those buying and building on the lot. However, a prerequisite for applying this instrument is that the municipality is owner of the property in question, since only the property owner has these rights over the property (www.cenergy.dk). This regulation can also be implemented by municipalities through processes usually involved in local building projects like Procurement (municipal property or building development), Tenders for urban land development, Contracts (agreements with contractors).

- **Electricity Savings Trust (S):** The Energy Saving Trust is a not-profit organization funded by Government and the private sector. The Trust makes use of a comprehensive range of different initiatives to influence the market, including product development, voluntary agreements with producers and suppliers, information campaigns, subsidies, fixed price agreements, making electricity consumption visible and advice (EST, Denmark). The EST has successfully created a supply chain between the producers and consumers by web-based price lists of energy efficient products, current retailers, and the cheapest product prices with a few clicks of the mouse (Denmark energy policy revised). The centre guarantees sale of energy efficient appliances for producers by encouraging consumers through subsidies. Thus EST has provided a win-win situation in the supply and demand side of the market. The funding of the EST is available through a 0.01 Euro/kWh levied on the electricity consumed by the households in Denmark.

- **Demonstrating Model houses (S):** Model houses built in collaboration with manufacturing companies are used to demonstrate the comforts, technology used in the house and possible energy savings to the customers.
Energy neutral housing developments

The Albertslund & Hyldeospjældet project have initially developed model house. These houses are used to promote the low energy concept among the future buyers. This way, the investors/builders can get peoples feedback and make necessary changes to houses. This way they can reduce the risk in selling houses in future as the houses are built to the customer preferences.

- **Collaboration (S):** Municipalities in Denmark have collaborated with material and technology manufacturers to ease the difficulties in construction and renovation of energy efficient houses. The manufacturers provide technical expertise and also help in marketing these houses among the customers thereby increasing the chances of success of the project. Albertslund municipality has established a unique collaboration with big manufacturing companies like Danfoss, Velux, and Rockwool etc for development of carbon neutral and energy efficient housing in its Hydespjældet project.

- **Energy taxes (R):** Energy taxes and CO₂ tax are levied energy used in households coming from fossil fuels. Today households and the public sector pay electricity taxes corresponding to 0.09 Euro/kWh plus 25% VAT. Taxes are used for all fossil fuels. The highest tax is paid for electricity used by households and in the public sector. Also energy used for heating have a high tax in all sectors (Togeby et al., 2007).

**4.2.2 Renewable Energy & technology:** The Danish energy policy aims to promote sustainable energy development and comply with commitments to reduce greenhouse gas emission. As a result it has laid a primary focus to achieve 35% of energy from renewable energy sources by 2030. They have primarily focussed on increasing the share of wind and bio-fuels in electricity production (Niels I. Meyer, 2004). The Danish municipalities have greatly encourage the consumer participation in renewable energy generation through community owned energy generation and district heating.

- **Community owned energy generation:** In Denmark, much of the energy sector is in the hands of nonprofit cooperatives, with residents as shareholders, which makes it easier for government to direct policy with little opposition from business interests (postcarboncities.net). The generation of low carbon electricity at a community level using different technologies, including photovoltaic, wind turbines, biomass-based systems and District combined heat and power (CHP). The common theme is therefore the delivery (of heat or energy) to groups of homes, ideally resulting in an increase in energy efficiency and a reduction in household CO2 emissions.

- **Electronic Monitoring Systems:** To regulate efficient usage of energy at homes the Samso Municipality has invested in an electronic energy monitoring system, where one person with a PC can monitor and control the energy consumption in all buildings. (Samso Energy Company)

**4.2.3 Financial support:** Danish government made use of options like electricity taxes, subsidies to invest in electricity saving, information campaign, and supporting research and development measure. In Denmark, a total of approximately 86 million Euro is spent every year on measures to promote energy efficiency in round figures 40 million Euro for the

---

7 Case study on Community wind farm is presented in the appendix I.
Energy neutral housing developments

activities of the energy companies (paid by all energy users), 32 million Euro for energy labelling of buildings (paid by those acquiring the label), and 14 million Euro for the Danish Electricity Saving Trust (collected by a special tariff on electricity for households and the public sector) (Togeby et al., 2009). To support the stakeholders to comply with the regulations Denmark has introduced various financial incentives.

- **Tax exemption(s):** Revenues from a community owned cooperatives in Denmark are tax exempt. With a tax rate of about 50%, this is an extremely attractive incentive and is the driving force for cooperative investments. The revenue from a house owner’s investment in a wind turbine cooperative is tax exempt if the wind turbines are located within their own commune or an adjoining commune.

- **Subsidies(s):** Denmark has been able to successfully provide incentives for investments in energy efficiency, carbon reduction and renewable technology over a long term by reinvesting the money collected from energy taxes back into subsidies and other incentives.
4.3 United Kingdom
In housing sectors the government aims that by 2015 no old home will lack the basic energy efficient measures. From 2016 all new homes will be built to a new zero carbon standards. By 2020 seven million homes will have been upgraded to significantly improve the energy performance. By 2050 the nation’s entire housing stock will be virtually zero carbon (Energy saving trust, UK). 10% of energy generation from renewable sources is set for 2010. Setting a medium term challenging target in the UK has proved a real driver for change in the home building industry. Home builders have displayed more innovation in the past three years than they have in the three preceding centuries as they rise to the challenge of cutting carbon emissions. The Government’s decision to set a deadline for zero carbon homes had been a brave one and had led to a sea change in the way the industry looked at emissions (Zero carbon hub).

4.3.1 Carbon reduction: The domestic sector accounts for 27% of UK’s CO2 emissions and is critical to tackling climate change. It is essential to reduce emissions from both new and existing homes. Boardman et al (2005) estimated that of the 23.9million homes already in existence, 21.8million of them will still exist in 2050. An additional 10million homes need to be built by 2050. In order to deliver a 60% reduction in CO2 from homes by 2050, these new homes would have to be near-zero carbon. To promote carbon reduction in housing developments the following regulation and support instruments have been employed by the UK local councils.

- **Sustainable building code(R):** The UK Code for Sustainable Homes (CSH) is particularly relevant to Decentralized Energy Technologies as it includes detailed provisions on energy performance. These CSH standards will be gradually made mandatory by inclusion in the Building Regulations which means that by 2016 all new homes built in the UK should be net zero-carbon, i.e. top Level 6 certification of the current CSH, thus providing a significant boost to microgeneration. (Decentralized.pdf)

- **Carbon Emissions Reduction Target funding(R):** The Carbon Emissions Reduction Target (CERT) is a legal obligation on the six largest energy companies to achieve carbon dioxide emissions reductions from domestic buildings in Great Britain. The obligation ensures the energy companies will need to spend £2.8 billion between 2008 and 2011 on carbon reduction measures in order to meet their targets. Suppliers meet their targets by promoting (e.g. through subsidy) the take-up of energy saving measures, including loft and cavity wall insulation and high-efficiency lighting and appliances.

- **Demonstration projects (s):** A £17m government initiative to trial different low carbon technologies in projects across the UK. Around 87 projects will receive around £150,000 to demonstrate the deep cuts in CO2 emissions required to help the UK meet its commitment to cutting carbon emissions by 80% by 2050. They will all then be monitored for two years by the Energy Saving Trust (EST), which will collect data on internal and external temperatures, humidity and CO2 emissions (Article, Guardian.co.uk)

---

8 A public/private partnership established to take day-to-day operational responsibility for coordinating delivery of low and zero carbon new homes in UK
• **Microgeneration certification scheme (s):** The MCS is the only certification scheme to cover all microgeneration products and services, and has support from the Department of Energy and Climate Change, industry and non-governmental groups as a prime method for making a substantial contribution to cutting the UK’s dependency on fossil fuels and carbon dioxide emissions. The Microgeneration Certification Scheme (MCS) is a UKAS accredited certification scheme third party certification scheme for installers and products, offering consumers OFT level protection. MCS or an equivalent mark for solar thermal products is already mandatory for access to LCBP grants. It is linked to feed-in tariffs. (MCS, 2006)

• **Low Carbon Buildings Programme (s):** Under the LCBP phase 1 department of Energy change and climate (DECC) provides grants to households for the installation of microgeneration technologies. A total grant of 85 million pounds has been issued under the two phases of LCBP from 2006 till 2010. The microgeneration technologies installed under this programme have produced lifetime carbon savings of 300,000 tonnes of CO2 (Source: Wikipedia)

• **Energy performance certificate (R):** When a house is put for sale or rent on the market, the owner has to create a Home Information Pack (HIP) and make a wide range of information available. The EPC is a compulsory element of this and the owner can’t get out of producing the EPC in the UK. Thus applying for a certificate has almost become an automatic procedure” (Source: Nyenrode University, 2010).

4.3.2 **Renewable energy & Technology:** To meet 15% renewable energy target by 2020, the Renewables Obligation (RO) is the UK’s main mechanism for supporting generation of renewable electricity. A 2005 study by the Energy Savings Trust suggested that by 2050, micro-generation could provide 30 to 40 per cent of the UK’s electricity need while reducing household carbon emissions by 15 per cent annually. The Energy White Paper and subsequently, the UK Energy Act of 2004 have set the initiative to encourage the installation of microgeneration technology, through clear Skies (solar thermal), and the Major Photovoltaic Demonstration Programme with total funding over 4 years of around £ 42.5 million (Energy saving trust,2005). Such initiatives aim to drive microgeneration technologies in conjunction with energy efficient measures so that a real impact on overall carbon neutral energy demand in buildings can be achieved. (Source: UK.pdf)

• **Eased Planning permits:** The development rights for renewable technologies introduced on 6th April 2008 and, have lifted the requirements for planning permission for most domestic microgeneration technologies. The General Permitted Development Order grants rights to carry out certain limited forms of development on the home, without the need to apply for planning permission.

• **Merton rule (R):** The 'Merton Rule' is the groundbreaking planning policy, developed by Merton Council, which requires the use of renewable energy onsite to reduce annual carbon dioxide (CO2) emissions in the built environment. This planning policy requires new housing developments (10 houses together or for every 1000m²) to generate at least 10% of their energy needs from on-site renewable energy equipment. (Source: Merton council, 2003)

• **Decentralized energy generation for housing communities:** UK government has set a target for achieving zero-carbon homes by 2016. These homes will need to be energy efficient and fuelled by a non-carbon emitting energy source. The provision
Energy neutral housing developments

of decentralized renewable energy systems in new housing developments will play a role in achieving this. (Source: Thames gateway). The housing growth programme employed in UK offers an opportunity for accelerating the deployment of decentralized renewable energy systems in the UK. It has recently been predicted that microgeneration could provide 30-40% of the UK’s electricity needs by 2050 (Energy challenge, 2006)

- **SMART meters**: In October 2008 the Government announced its intention make the installation of smart gas and electricity meters mandatory for all households. (EST)

4.3.3 **Financial support**: UK municipalities have promoted financial & facilitation support mainly aimed at encouraging use of microgeneration technologies in households to reduce carbon emissions. They have quickly realized that to be able to expand renewable energy generation some form of financial assistance is needed because other forms of heat are currently cheaper. So its support policies are aimed at making generation of renewable energy more affordable to a wider range of people and, by expanding the market, help bring costs down more quickly.

- **VAT Reduction & Stamp duty relief**: VAT reduction on all micro-generation technologies used in households is available. The VAT has been reduced from 17.5% to 5%. The stamp duty relief will provide exemption from tax liability when house costs less than £500,000, and will provide a £15,000 reduction in tax liability to all homes worth more than £500,000. (Regulatory impact assessment, 2007)

- **Feed in tariffs**: Under this scheme energy suppliers make regular payments to households and communities who generate their own electricity from renewable or low carbon sources. The generation tariff paid to producer will change each year for new entrants to the scheme (except for the first 2 years), but once joined the tariff is same for 20 years, or 25 years in the case of solar electricity (PV). The benefits from feed in tariff for an average household using 4500kwh/year with 2.5 kW of solar PV have been calculated as £830 (€ 967) per year by adding up the generation tariffs, export tariff and energy bill savings. The assumption is that more than 50% is transported. (Energy saving trust, UK)

- **Property based green loans**: The improvement criteria considered for loans include insulation and micro-renewables such as small wind turbines and ground source heat pumps. The repayments for improvements are structured in a Pay-As-You-Save manner (repayments set to be less than the projected savings), the loans will leave more money in the back pockets of the occupants. The loans will be tied to properties rather than individuals too, so that if a family move before payback on the loan, then the next occupants will be responsible for the repayments as they also enjoy the benefits (Somar, 2010)

- **Renewable Heat incentive**: The Renewable Heat Incentive (RHI) planned for 2011 will provide financial support for a range of technologies, including air and ground-source heat pumps (and other geothermal energy), solar thermal, biomass boilers etc in all sectors including new and existing households. (Source: RHI, 2010)
4.4 Role of Danish Municipalities

Denmark has made some impressive advances due to consistent policy over more than 30 years, a strong research base, diffusion to construction stakeholders, as well as a clear communication strategy to and acceptance by inhabitants. Danish municipalities’ commitment to promote energy efficient buildings has shown great potential to supplement and support these national initiatives. This potential is reflected in the manner they plan, regulate and facilitate different aspects of the energy efficient housing developments. The Danish municipalities have taken deliberate steps to actually enforce the municipal objectives of promoting energy efficient buildings by putting powerful regulation instruments into use and by having a close dialogue with implicated stakeholders during the process. The role played by municipalities in the planning, implementation and realization phases of the energy efficient housing projects and resulting successful regulations & support instruments adopted to materialize their efforts are described below.

1. Planning & development: The planning and regulation authority in Denmark is decentralized, in the sense that municipalities carry out planning and regulation of the built environment in compliance with national and regional interests. The municipalities exercise this authority through municipal and local planning documents to be worked out for urban development areas, and when processing specific building projects. However they need to ensure that the framework laws, Building Law and the Planning Act are enacted in all urban development projects. The Danish municipalities are promoting the concept of developing more proactive municipal planning practices that boost promotion of energy efficient buildings. This means municipalities are more reflexive about their own role as planning authority and actively engage in discussions of how to develop new planning cultures (Jørgensen et al. 2006).

Role of municipalities:

- Under proactive role: as planning authority, the municipality can make sure that sustainability considerations are incorporated into urban planning as well as in the so called ‘local plans’; As property owner, the municipality can consider to set stricter requirements in connection to usage or sale of a municipal property; As developer or operator, the municipality can incorporate energy efficiency and sustainability; As authority in relation to approval of building projects, the municipality can assure a dialogue with private developers in relation to sustainability and disseminate information (Municipality of Stenløse 2004)
- The technical administration of the Egedal municipality made extra efforts in formulation of tender documents and informative brochures regarding expected costs, type of material and technology used etc in relation to the required involvement and expertise of developers during the development process.
- The Municipalities have also involved the citizens in the planning of energy efficient developments and thus increased their attention towards energy efficient housing.
- The municipalities are setting requirements that were lower than the minimal requirements in Denmark in order to promote more sustainable building practices among the project developers.
- With the new planning & building regulations reforms, the municipalities could impose strong authority over requirements for new developments using local plans.
Energy neutral housing developments

- The details of the urban development project are formulated in municipal plans and the local plans to communicate the strategies and requirements of this urban development area to relevant stakeholders.

**Resulting instruments employed:**
- With the strengthened building code including low energy classes 1 & 2 has allowed municipalities to set lower requirements than necessary.
- The Kolding municipality has decided that requirements in new local plans (and municipal buildings) must comply with the low energy class 1. The municipality chose to take the full step instead of using resources to manage an intermediate stage with requirements of low energy class 2 in local planning and reviews of building licenses (Kolding municipality, 2009)
- Egedal municipality has imposed easements (energy efficiency requirements are legally binding for developers or individual house owners for buying & building on the offered land from municipality)
- Egedal municipality involved its citizens in the planning phase using Obligatory public hearings of the different planning documents were.

**2. Implementation & realization:** The municipalities have not just been active in regulating planning instruments but are also involved in facilitating the implementation process in practice. They have been active in the implementation phase so that the relevant stakeholders actually become involved in the process and comply with the requirements set up by the municipality. The municipalities have acted as a kind of spokesperson for promoting energy efficiency in the building projects carried out in the area, ensuring a translation of the municipal strategies into specific changes in building practices. This represents a new and more proactive municipal role than the traditional spatial planning normally adopted, involving new planning practices with emphasis on facilitating sustainable changes in local building projects (Sehested 2002)

**Role of Municipalities:**
- The Danish municipalities have succeeded in putting regulation instruments to use, by having a close dialogue & contractual agreements with contractors & developers during the process.
- The municipality’s involvement in all of the phases of the design and development of the entire project has assured that the involved stakeholders address and comply with their outlined strategies for development.
- The actual level of energy performance required for the developments was assessed by considering the economic implications of different levels of energy performance and helped the developers comply with these by providing technical assistance. The expert assistance has been a prerequisite to assure progress in the project, for the developers not to give up along the way due to difficulties with handling technicalities in relation to the low-energy requirements.
- The Danish municipalities are aiming at a viable level of energy efficiency requirement based on the idea of implementing already available energy efficient technologies that developers and contractors would find acceptable. So the intention has not been to implement radical sustainable requirements, but rather to ensure incremental improvements of the energy efficiency of buildings.
Energy neutral housing developments

- The municipalities have supported the project developers to collaborate with technology and material manufacturers. Manufacturers helped in constructing model houses and specific information on technology & cost savings in low energy buildings is given to customers.
- Regulated obligations instruments on the households.
- Egedal Municipality participated in the Concerto demonstration program to get valuable knowledge and information from other municipalities.

Resulting instruments employed:

- For “De Grønne Højder”, project the Naestved municipality encourages developers to build demonstration houses (expo houses) by giving upto 150,000 DKK in discounts on land (equivalent to a price reduction on (18-30%) if they build according to energy class 0 and / or implement photovoltaic cells on the roof (Roskilde Universitet, 2009)
- Naestved Municipality has released a catalogue giving guidelines to developers for building sustainable houses.
- Microgeneration systems have been successfully employed to generate renewable energy in Stenløse since in the new Danish building regulations dispensation from obligation to connect to collective systems can be given in cases of low energy buildings.
- The Albertslund & Hyldespjældet project have initially developed model house by collaborating with technology manufacturers. These houses are used to promote the low energy concept among the future buyers. This way, the investors/builders can get peoples feedback and make necessary changes to houses. This way they can reduce the risk in selling houses in future as the houses are built to the customer preferences.
- The Hillerød Municipality promoted renewable heat and electricity using community participation among the residents of its low energy housing community “Ullerød-byen” by setting up a solar farm and wood pellets-biomass plant maintained by a nonprofit company owned by the community residents.
- Egedal municipality provided technical assistance for its developers through collaboration of municipal technical advisors and local energy companies and.
- The Danish municipalities are aiming at a viable level of energy efficiency requirement based on the idea of implementing already available energy efficient technologies that developers and contractors would find acceptable.
- Denmark in its new building code has set an obligation that connecting to district systems is not required in case of low-energy buildings.
Energy neutral housing developments

4.5 Conclusions

**Instruments**: This chapter answers the question 1.1 of research. “What are the successful regulatory & support instruments currently employed in EU member states like Denmark & UK to achieve their energy ambition in housing sector?”

- The Danish regulatory & support instruments favoring Danish municipalities’ local ambitions are focussed on improving the energy efficiency of households and promoting renewable energy usage in housing sector through community owned cooperative farms.
- UK on the other hand has heavily employed support instruments focussed mainly on carbon reduction in households. Numerous financial support instruments like renewable heat incentive, LCBP grants, reduced VAT & Stamp duty etc. to promote carbon reduction using microgeneration technology and decentralized energy sources.
- By playing a pro-active role and effectively participating in all phases of the project Danish municipalities have helped to successfully realize such developments. By taking a proactive role, the municipalities were able to regulate the developers to build energy efficient homes by bringing the local plans to effect as the owner of the land, planning authority and also as approval authority. By participating in the implementation phase and realization phase the Danish municipalities were able to promote effective collaboration between stakeholders. This was possible since municipality was able to understand the difficulties faced by the developers and customers in relation to the new concepts of energy efficient homes. They have used unique facilitation support instruments like collaboration with manufacturers, Micro generation certificate scheme, and model houses etc. to encourage the project developers and house owner’s participation in developments. Thus the Danish municipalities have shown that “the type of instruments that can be adopted to favor energy efficient housing project is dependent on the role municipality plays in the development process of the project”.

**Evaluation of Instruments**: The instruments employed in Denmark & UK has all not been effective. Some highlights regarding the employment effect of the instruments are discussed below.

- The Danish labelling system exceeds current EU minimum requirements in terms of ambition and extent. Local study has shown that there is no significant difference between buildings with or without building labels. The cost of labels with respect to the energy savings has be found to be higher.
- Without the energy taxes the Danish energy consumption would be at least 10% higher. Half of the companies respond that ETS has increased their focus on energy efficiency to some or to a high extent. However the taxes are national instruments, so municipalities are dependent on national reforms.
- In energy obligations for companies the energy saved is in terms of kWh even though the cost of savings varies with energy type. So savings from CHP based on natural gas and electricity from coal have same value. This feature is totally different from other European nations like UK, France and Italy. This has lead to some conflict situations among the energy companies.
Energy neutral housing developments

- The Danish building code promotes onsite renewable energy for low energy class houses. However some other alternative energy providers like district heating is cheaper. These extra costs are covered with sufficient incentives.
- RHI has just been introduced in UK, therefore its effect on the successfully promoting microgeneration is not clear yet. SMART meters are just introduced, therefore their practical advantages have not yet been evaluated.

**Role of Danish Municipalities:** This conclusion answers the question 2.1 of the research. The Danish municipalities have realized the energy efficient projects by playing a proactive role. They have taken an active part in all the phases of the project and successfully promoted stakeholder participation. They have satisfied the interests of different stakeholders by playing a participatory role i.e. the diverse stakeholders and their interests are engaged together in reaching for a consensus on a plan and its implementation. The highlights of role played by Danish municipalities are shown in the figure 6.

![Figure 6: Highlights of Participatory role played by Danish municipalities](image)

- Proactive role
- Employ regulations through local plans
- Citizens involvement through public hearings
- Communicate strategy to stakeholders through local plans
- Technical & financial advice to developers

- Close dialogue and Contractual agreements with stakeholders.
- Expert advise to developers through energy consultants
- Involve manufacturers
- Promote customer participation

- Obligations to consumers
- Demonstration programmes
- Financial incentives
### Energy neutral housing developments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Focussed on</th>
<th>Implementation</th>
<th>Targeted stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strict building code</td>
<td>Energy efficiency</td>
<td>Regulation</td>
<td>House owners, Project developers</td>
</tr>
<tr>
<td>Energy labeling</td>
<td>Energy efficiency</td>
<td>Regulation</td>
<td>House owners/ end users</td>
</tr>
<tr>
<td>Energy obligations for companies</td>
<td>Energy efficiency</td>
<td>Regulation</td>
<td>Energy companies</td>
</tr>
<tr>
<td>Easements</td>
<td>Energy efficiency, carbon reduction</td>
<td>Regulation</td>
<td>Project developers,</td>
</tr>
<tr>
<td>Electricity saving trust</td>
<td>Energy efficiency</td>
<td>Facilitation &amp; Financial Support</td>
<td>House owners/ Consumers</td>
</tr>
<tr>
<td>Demonstration/ Model houses</td>
<td>Energy efficiency, Carbon reduction</td>
<td>Facilitation Support</td>
<td>House owners/consumers</td>
</tr>
<tr>
<td>Collaboration with manufacturers</td>
<td>Energy efficiency, Carbon reduction</td>
<td>Facilitation Support</td>
<td>Project developers, Energy consultants,</td>
</tr>
<tr>
<td>Energy taxes</td>
<td>Energy efficiency, Carbon reduction</td>
<td>Regulation</td>
<td>House owners/consumers</td>
</tr>
<tr>
<td>Subsidies</td>
<td>All fields</td>
<td>Financial support</td>
<td>Project Developers, House owners</td>
</tr>
<tr>
<td>Tax exemption</td>
<td>Renewable energy</td>
<td>Financial Support</td>
<td>House owners/consumers</td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Merton rule</td>
<td>Energy efficiency</td>
<td>Regulation</td>
<td>Project Developers</td>
</tr>
<tr>
<td>EPC</td>
<td>Energy efficiency</td>
<td>Regulation</td>
<td>House owners</td>
</tr>
<tr>
<td>Sustainable building code</td>
<td>Carbon reduction, Renewable energy</td>
<td>Regulation</td>
<td>House owners, Project developers</td>
</tr>
<tr>
<td>CERT/energy obligations</td>
<td>Carbon reduction</td>
<td>Regulation</td>
<td>Energy companies</td>
</tr>
<tr>
<td>Demonstration projects</td>
<td>Carbon reduction, renewable energy</td>
<td>Facilitation Support</td>
<td>Project developers, house owners/consumers</td>
</tr>
<tr>
<td>Microgeneration certification scheme</td>
<td>Renewable energy</td>
<td>Facilitation Support</td>
<td>House owners, project developers</td>
</tr>
<tr>
<td>LCBP subsidies</td>
<td>Renewable energy</td>
<td>Financial Support</td>
<td>House owners/consumers</td>
</tr>
<tr>
<td>Eased planning permits</td>
<td>Renewable energy</td>
<td>Facilitation Support</td>
<td>House owners, project developers</td>
</tr>
<tr>
<td>Reduced VAT &amp; stamp duty relief</td>
<td>Renewable energy</td>
<td>Financial Support</td>
<td>House owners, project developers</td>
</tr>
<tr>
<td>Feed in tariffs</td>
<td>Renewable energy</td>
<td>Financial Support</td>
<td>House owners/consumers</td>
</tr>
<tr>
<td>Renewable heat incentive</td>
<td>Renewable energy</td>
<td>Financial Support</td>
<td>House owners/consumers</td>
</tr>
<tr>
<td>Property based green loans</td>
<td>Renewable energy</td>
<td>Financial Support</td>
<td>House owners/consumers</td>
</tr>
</tbody>
</table>

Table 2: Summary of instruments employed in Denmark & UK.
Energy neutral housing developments

**Research question:** Based on the findings it is now interesting to see which of these instruments are suitable for Eindhoven scenario and how can they be adopted. Apart from this it is also interesting if the role played by Danish municipalities can be useful for Eindhoven municipality. Thus this chapter gives raise to the following questions

| 1.2 How are the instruments found from UK & Denmark are prioritized for Eindhoven scenario? |
| 1.3 How can these instruments be adopted for Eindhoven scenario? |
| 2.2 What role is needed to be played by the municipality to promote stakeholder participation in the various phases of energy neutral housing developments? |
5 SURVEY

5.1 Introduction
The following paragraphs describe how the instruments found from the desk research on Denmark & UK is put into survey to validate their importance for & stakeholder priorities for Eindhoven scenario. The method used for designing the questionnaire, design of the questionnaire, survey respondents and the results of the survey are described in this chapter. The objective of this survey is to set the weights of the instruments (criteria) and priorities for different stakeholder groups. Therefore, the result of this survey by applying AHP to analyze the importance of instrument priorities would show how priorities/preferences of stakeholders are important for realization of energy neutral housing developments.

5.2 Analytical Hierarchy Process
AHP provides a proven, effective means to deal with complex decision making and can assist with identifying and weighting selection criteria, analyzing the data collected for the criteria and expediting the decision-making process (Saaty, 1980). AHP enables people to relate intangibles to tangibles, the subjective to objective and to link both to their purposes. It offers a way to integrate complexity, set the right objectives, establishes their priorities and determines the overall value of alternative solutions. AHP used hierarchical decision models and it has sound mathematical basis. Different steps involved in AHP are as follows (Hsin-Pin Fu et al, 2009)
• Identify the decision problem
• Ascertain that the problem can be solved by AHP
• Hierarchy Structure of the decision problem & relevant criteria
• Establish the matrices for paired comparison
• Measure the consistency ratio.
• Calculate the priority weights of each criterion

Decision Problem
According to Hsin-Pin Fu et al, 2009 energy projects are evaluated in project performance by using the equal weights of performance criteria. Most studies, unfortunately, do not consider the importance degree of performance criteria. But infact the weights of performance criteria will be changed in different projects depending on local conditions. The criteria of performance measurement are usually used to evaluate the project performance which is measured by appropriate performance criteria to reflect realistic outcomes, and also to examine whether the project outcome meets with the original objectives and expected benefits of a project. Therefore, the basis for the validity for performance measurement should be the established weighted performance of criteria (Luu et al., 2008).

The research so far shows that the outcome of the energy neutral housing developments is dependent on the type of regulatory and support instruments employed. These instruments found from desk research on Denmark & UK are successfully employed to achieve the local energy ambitions in their respective housing sectors. Thus in the energy neutral developments these regulatory and support instruments can be assumed as the performance criteria for determining the outcome. But the effectiveness/ priority of
Energy neutral housing developments

performance criteria vary widely depending on the development and implementation of energy ambitions of different regions (Blair Hamilton, 2010).

- As a result in order to find the most suitable instruments for energy neutral developments for the local Eindhoven scenario, it is important to know “what is the relative importance of these instruments in local stakeholders’ perspective?”
- To know the relative importance there is a need to quantify the instruments against each other which requires calculating the priority weights of these instruments.
- Further it is also interesting to find out how the preferences of these instruments differ from one stakeholder group to another.

**Need for AHP**

The AHP is a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, sub criteria and alternatives. The pertinent data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion (Evangelos Triantaphyllou et.al, 1995). Weighing of the selected criteria in other terms also means prioritizing each individual criterion among other given criteria.

Thus, for the context of this survey, AHP can be used to find the weights of the given set of performance criteria for Eindhoven scenario. With the given decision problem of finding the prioritized instruments for energy neutral housing in Eindhoven, AHP can be used to find the weights of the instruments (performance criteria) found from the research and thus find the relative importance of once criteria over the other. This way the most prioritized/preferred Instruments for Eindhoven scenario can be found out.

**Hierarchy Structure of Relevant criteria**

After the decision problem and the need for AHP have been discussed in the above paragraphs the next important step in AHP is to develop a Hierarchical decision model based on the problem discussed in the research context. This decision model consists of three different levels which are described below:

- **Goal:** The prioritized instruments for Eindhoven scenario
- **Criteria:** The four main target areas for achieving energy neutral housing developments namely Energy efficiency, Carbon reduction, Renewable technology and financial support.
- **Sub Criteria:** These are the performance characteristics which will determine the outcome of the respective main target areas and thus indirectly energy neutral housing development. The Hierarchy decision model for this research is shown in the figure 7.
5.3 Questionnaire Design & Respondents

Based on this model the questionnaire for survey is designed to obtain the weights of the performance criteria and the overall priorities of these criteria. The questionnaire for survey is designed to find the weights of the performance criteria using pairwise comparison approach which was proposed by Saaty (1980). Pairwise comparisons are used to determine the relative importance of each alternative in terms of each criterion. In this approach the respondent has to express his opinion about the value of one single pairwise comparison at a time. Usually, the respondent has to choose his answer among 10-17 discrete choices. Each choice is a linguistic phrase like "A is more important than B", or "A is of the same importance as B", or "A is a little more important than B", and so on (Evangelos Triantaphyllou et.al, 1995)

For determining pairwise comparison through a questionnaire the criteria within each hierarchy should be evaluated against their corresponding criteria in the level above, and then compared in pairs between themselves. That means if there are “n” criteria in one hierarchy, there must be n(n-1)/2 number of paired comparisons conducted. Using this pairwise comparison approach a total of 38 questions are framed for the questionnaire. The sequence of questions framed in the questionnaire is discussed below.

- For the four main criteria 6 pairwise comparison questions were framed. The number of questions is calculated based on the simple expression 4*(4-1)/2
- Pairwise comparison questions were framed for the sub criteria under each main criterion. For example, the main criteria Energy efficiency and Carbon reduction have 5 sub-criteria each. So using the above combination formula 10 questions are framed for their respective sub-criteria and thus in total 20 comparison questions are framed.
- Similarly for the remaining two main criteria Renewable technology & Financial support which consist of 4 sub criteria each, a total of 12 comparison questions are framed.

Further five discrete choices for each question were chosen. The respondent had to choose one among the five choices presented for each question and the weightage for the criteria
Energy neutral housing developments

was calculated based on the assigned values for each of these discrete choices explained in the analysis part. Examples of the questions framed for main and sub criteria as used in the survey are shown in the table 3 & 4.

The questionnaire\(^9\) was created online using the Google Docs and sent to surveyors via e-mail. The surveyors are representatives from the stakeholder groups Municipality of Eindhoven, Energy consultants, Housing project developers and End-use customers. Along with the questionnaire a document containing detailed explanation of the research goal and criteria was sent. The respondents could refer to this document while answering the questionnaire. The whole document can be seen in the Appendix III. Only representatives with background knowledge regarding Eindhoven’s energy neutral ambitions were chosen. Energy consultants within the Eindhoven region were chosen. Representative for project developers were chosen from construction companies and the representative from municipality were chosen from Gemeente Eindhoven & Provincie Brabant. For customer group\(^10\), students & professors with background knowledge in energy neutral developments were chosen. In total the questionnaire was sent to 50 representatives out of whom 25 responded with their answers. This shows a response rate of 50%. The number of respondents from different stakeholder groups is shown in the figure 8.

![Survey respondents](image)

**Figure 8:** Summary of survey respondents

<table>
<thead>
<tr>
<th>Sample: To achieve energy neutral housing developments in Eindhoven how important are the instruments A and B in relation to each other?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Energy efficiency; B. Carbon reduction</td>
</tr>
<tr>
<td>A &amp; B are equally important</td>
</tr>
<tr>
<td>A is slightly more important than B</td>
</tr>
<tr>
<td>A is absolutely more important than B</td>
</tr>
<tr>
<td>B is slightly more important than A</td>
</tr>
<tr>
<td>B is absolutely more important than A</td>
</tr>
</tbody>
</table>

Table 3: Question for pairwise comparison of main criteria

---

\(^9\) Online link under Appendix IV.

\(^10\) CME students at Tu/e were chosen as they are currently researching on topics related to energy neutral ambitions of Eindhoven and also they represent the common customer in general perspective.
Energy neutral housing developments

<table>
<thead>
<tr>
<th>Sample: To achieve energy efficiency in housing developments in Eindhoven how important are the instruments A and B in relation to each other?</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Stricter Building code; B. Obligation for energy companies</td>
</tr>
<tr>
<td>A &amp; B are equally important</td>
</tr>
<tr>
<td>A is slightly more important than B</td>
</tr>
<tr>
<td>A is absolutely more important than B</td>
</tr>
<tr>
<td>B is slightly more important than A</td>
</tr>
<tr>
<td>B is absolutely more important than A</td>
</tr>
</tbody>
</table>

Table 4: Question for pairwise comparison of sub-criteria.

### 5.4 Analysis & Results

The responses from online survey are automatically worked out into a excel spread sheet. The first task was to convert the discrete choices made by the respondents into a numerical value. The values of the pairwise comparisons in the AHP can be determined according to the scale introduced by Saaty (1980). According to this scale, the available values for the pairwise comparisons are members of the set: \{9, 8, 7, 6, 5, 4, 3, 2, 1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9\}. Using this scale the following values shown in the table 5 have been fixed for each choice.

<table>
<thead>
<tr>
<th>Value</th>
<th>Discrete choice comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A and B are equally important</td>
</tr>
<tr>
<td>3</td>
<td>A is slightly more important than B</td>
</tr>
<tr>
<td>5</td>
<td>A is absolutely more important than B</td>
</tr>
<tr>
<td>1/3</td>
<td>B is slightly more important than A</td>
</tr>
<tr>
<td>1/5</td>
<td>B is absolutely more important than A</td>
</tr>
</tbody>
</table>

Table 5: Assigned values for the discrete choices.

### Reciprocal & Normal Matrices

The above values are assigned to the responses obtained from the survey. The mean value for each of the 38 questions is calculated using this mathematical formula. 

\[
(a_1, a_2...a_n) = (\prod_{i=1}^{n} a_i)^{1/n}
\]

\[
\Rightarrow G(a_1, a_2, a_3) = (a_1 \times a_2 \times a_3)^{1/3}
\]

(Where G=Geometric mean, q= Pairwise comparison scale given by the respondent, n=Number of experts)

Reciprocal Matrix and Normalized Matrix are found to calculate the priority weights of the criteria. The calculated reciprocal and normalized matrix along with the Priority vector for the main criteria is shown in the tables 6a & 6b respectively. Simple matrix mathematics is used to compute a priority vector for each set of criteria. The sum of each column is calculated. Each cell is then divided by its column sum and the rows added. The vector resulting from summing the rows is called the eigenvector (EV). The priority vector is the normalized eigenvector; normalized by dividing each eigenvector element by the elements sum. Similarly the reciprocal & normalized matrices are calculated for all the remaining sub-criteria and their priority weights are calculated.
Energy neutral housing developments

**Consistency Ratio**
The consistency ratio was calculated to test the condition of consistency in the data analysis. The CR is acceptable if it does not exceed 0.1 (10%). The CR was calculated for the main criteria using the formula and it proved consistent with 1.01% (<10%). The “λ max” is the maximized eigenvector of a pair-wise comparison matrix. The “n” is an attribute of the matrix i.e. the number of criteria, and “RIn” is a random index which is a constant for given “n” value (Teknomo, Kardi. 2006)

\[ CI = (\lambda_{max} - n) / (n-1) \text{ and } CR = (CI / RIn) \]

6a. Reciprocal Matrix (RM):

<table>
<thead>
<tr>
<th>Main criteria</th>
<th>Energy Efficiency</th>
<th>Carbon Reduction</th>
<th>R.Energy &amp; Tech</th>
<th>Financial support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficiency</td>
<td>1</td>
<td>1.75</td>
<td>1.41</td>
<td>1.02</td>
</tr>
<tr>
<td>C.Reduction &amp; Micro Gen</td>
<td>0.57</td>
<td>1</td>
<td>0.82</td>
<td>0.71</td>
</tr>
<tr>
<td>R.Energy &amp; Technology</td>
<td>0.71</td>
<td>1.22</td>
<td>1</td>
<td>0.82</td>
</tr>
<tr>
<td>Financial support</td>
<td>0.98</td>
<td>1.42</td>
<td>1.22</td>
<td>1</td>
</tr>
<tr>
<td>Sum</td>
<td>3.26</td>
<td>5.39</td>
<td>4.45</td>
<td>3.55</td>
</tr>
</tbody>
</table>

6b. Normalized Matrix (NM):

<table>
<thead>
<tr>
<th>Main criteria</th>
<th>Energy Efficiency</th>
<th>Carbon Reduction</th>
<th>R.Energy &amp; Tech</th>
<th>Financial support</th>
<th>SUM (EV)</th>
<th>Priority Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficiency</td>
<td>0.31</td>
<td>0.33</td>
<td>0.32</td>
<td>0.29</td>
<td>1.24</td>
<td>0.309</td>
</tr>
<tr>
<td>C.Reduction &amp; Micro Gen</td>
<td>0.17</td>
<td>0.19</td>
<td>0.18</td>
<td>0.20</td>
<td>0.74</td>
<td>0.186</td>
</tr>
<tr>
<td>R.Energy &amp; Technology</td>
<td>0.22</td>
<td>0.23</td>
<td>0.22</td>
<td>0.23</td>
<td>0.90</td>
<td>0.225</td>
</tr>
<tr>
<td>Financial support</td>
<td>0.30</td>
<td>0.26</td>
<td>0.27</td>
<td>0.28</td>
<td>1.12</td>
<td>0.280</td>
</tr>
<tr>
<td>Sum</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>4.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 6 (a) & (b): The Reciprocal & Normalized Matrices calculated for main criteria along with the priority vector (weight).

5.4.1 Priority Weights of Criteria

The table 7 shows the ranking and priority weights of the main criteria and the priority weights of the sub criteria. These priority weights are calculated from the 25 responses obtained from all the stakeholder groups whose RM & NM calculations are shown above. The priority weights of the sub-criteria (performance criteria) belonging to the respective main criteria are also shown.

**Result:** The stakeholders prefer energy efficiency (0.309) and good financial support (0.280) as the main instruments to foster energy neutral ambitions in housing developments. Instruments like Stricter Building code (0.259) and Obligation on energy companies (0.254) are the most preferred to promote energy efficiency. The results also show that all forms of
Energy neutral housing developments

financial support are highly preferred with renewable heat incentive being the most preferred. Community owned generation (0.338) is preferred over micro generation (0.268) for generating energy through renewable sources. In stakeholders’ perspective carbon reduction is the least preferred instrument to foster energy ambitions in Eindhoven.

5.4.2 Priority weights of Individual stakeholder groups

Similar calculations are used to find the Reciprocal matrix & Normal matrix for the responses representing each group. The priority weights of the main and sub-criteria are found out from responses of each stakeholder group. For example, the RM & NM are found for the responses from 19 respondents representing customer group and the priority weights of main and sub-criteria are calculated accordingly. In the same manner the priority weights are calculated for respondents from Municipality (1), Housing project developers (3) & Energy consultants (2).

**Results:** The table 8 showing the priorities of individual stakeholder groups reveals conflicting priorities. These conflicting priorities (preferences/interests) are one of the reasons for lack of cooperation between stakeholders. Some of these conflicting priorities are explained in words.

- The municipality (0.541), Customers (0.282) and housing project developers (0.414) prefer energy efficiency the most, but the energy consultants (0.486) think the need for financial support is superior.
- On the other hand the municipality gives least preference to the financial support (0.059) where as the customers (0.277) & developers (0.286) give it the second best preference.
- Municipality prioritizes carbon reduction next to energy efficiency, where as other stakeholders prefer it the least.
- All the stakeholders prefer community generation whereas the municipality prefers microgeneration in combination with new technology (private wire) for producing renewable energy.

---

11 Explained as the reason for lack of cooperation between stakeholders under conclusions of chapter 3.
<table>
<thead>
<tr>
<th>Main criteria</th>
<th>Priority Weights</th>
<th>Sub-Criteria</th>
<th>Priority weights</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy Efficiency</strong></td>
<td>0.309</td>
<td>Building code</td>
<td>0.259</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Obligation companies</td>
<td>0.254</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mandatory E Label/EPC</td>
<td>0.182</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collaboration Manufacturers</td>
<td>0.151</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Easements</td>
<td>0.154</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ren Heat incentive</td>
<td>0.275</td>
</tr>
<tr>
<td><strong>Financial Support</strong></td>
<td>0.280</td>
<td>Reduced VAT/ stamp duty</td>
<td>0.268</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feed in tariffs</td>
<td>0.242</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Domestic green loans</td>
<td>0.215</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Community generation</td>
<td>0.338</td>
</tr>
<tr>
<td><strong>Renewable technology</strong></td>
<td>0.225</td>
<td>Micro-gen technology</td>
<td>0.268</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electronic monitoring</td>
<td>0.210</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grid independent</td>
<td>0.184</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Building code</td>
<td>0.262</td>
</tr>
<tr>
<td><strong>Carbon-reduction</strong></td>
<td>0.186</td>
<td>Obligation Energy supplier</td>
<td>0.247</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Obligation for households</td>
<td>0.182</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Planning permits</td>
<td>0.166</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MCS &amp; Demonstration</td>
<td>0.143</td>
</tr>
</tbody>
</table>

Table 7: Priority weights of criteria calculated from survey data.
Energy neutral housing developments

<table>
<thead>
<tr>
<th>Main Instrument</th>
<th>Sub-Instrument</th>
<th>Municipality</th>
<th>Project Developer</th>
<th>Energy Cons</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficiency</td>
<td>Building code</td>
<td>0.460</td>
<td>0.254</td>
<td>0.328</td>
<td>0.240</td>
</tr>
<tr>
<td></td>
<td>Obligation for companies</td>
<td>0.155</td>
<td>0.242</td>
<td>0.263</td>
<td>0.258</td>
</tr>
<tr>
<td></td>
<td>Mandatory E. label/EPC</td>
<td>0.250</td>
<td>0.216</td>
<td>0.161</td>
<td>0.174</td>
</tr>
<tr>
<td></td>
<td>Easements</td>
<td>0.044</td>
<td>0.129</td>
<td>0.139</td>
<td>0.170</td>
</tr>
<tr>
<td></td>
<td>Collaboration Manufacturers</td>
<td>0.092</td>
<td>0.158</td>
<td>0.114</td>
<td>0.158</td>
</tr>
<tr>
<td>Carbon reduction</td>
<td>Building code</td>
<td>0.469</td>
<td>0.252</td>
<td>0.328</td>
<td>0.243</td>
</tr>
<tr>
<td></td>
<td>Obligation for households</td>
<td>0.142</td>
<td>0.119</td>
<td>0.126</td>
<td>0.201</td>
</tr>
<tr>
<td></td>
<td>Obligation Energy supplier</td>
<td>0.259</td>
<td>0.348</td>
<td>0.216</td>
<td>0.231</td>
</tr>
<tr>
<td></td>
<td>Planning permits</td>
<td>0.079</td>
<td>0.143</td>
<td>0.100</td>
<td>0.184</td>
</tr>
<tr>
<td></td>
<td>MCS &amp; Demonstration</td>
<td>0.050</td>
<td>0.138</td>
<td>0.129</td>
<td>0.141</td>
</tr>
<tr>
<td>Renewable Technology</td>
<td>Community generation</td>
<td>0.058</td>
<td>0.357</td>
<td>0.573</td>
<td>0.330</td>
</tr>
<tr>
<td></td>
<td>Grid independent</td>
<td>0.499</td>
<td>0.181</td>
<td>0.099</td>
<td>0.220</td>
</tr>
<tr>
<td></td>
<td>Micro-gen technology</td>
<td>0.161</td>
<td>0.162</td>
<td>0.233</td>
<td>0.285</td>
</tr>
<tr>
<td></td>
<td>Electronic monitoring</td>
<td>0.282</td>
<td>0.300</td>
<td>0.190</td>
<td>0.164</td>
</tr>
<tr>
<td>Financial Support</td>
<td>Feed in tariffs</td>
<td>0.081</td>
<td>0.181</td>
<td>0.262</td>
<td>0.257</td>
</tr>
<tr>
<td></td>
<td>Domestic green loans</td>
<td>0.560</td>
<td>0.322</td>
<td>0.087</td>
<td>0.201</td>
</tr>
<tr>
<td></td>
<td>Reduced VAT/ stamp duty</td>
<td>0.279</td>
<td>0.178</td>
<td>0.248</td>
<td>0.276</td>
</tr>
<tr>
<td></td>
<td>Ren Heat incentive</td>
<td>0.081</td>
<td>0.319</td>
<td>0.403</td>
<td>0.265</td>
</tr>
</tbody>
</table>

Table 8: Calculated priority weights of individual stakeholder groups.

### 5.5 Conclusion

- This conclusion answers the research question 1.2 “How are the instruments found from UK & Denmark prioritized for Eindhoven scenario?” Table 7 shows the priorities of main criteria to be focussed for Eindhoven scenario. The overall prioritized instruments for Eindhoven scenario is determined by calculating the final weights of the sub criteria using table 7. Example: the final weight of Renewable Heat Incentive = Priority weight of RHI * Priority weight of Financial support = 0.275*0.280 = 0.077.

- The most preferred instruments for Eindhoven scenario are arranged in the rank wise order in table 9. The list of prioritized instruments reveals that stakeholder Building efficiency, energy efficiency obligations on companies have been chosen as the most needed instruments to improve energy efficiency in Eindhoven. Community generation for new housing developments and the need to support them using reduced VAT/ stamp duty and FIT’s is prioritized. Further Stakeholders believe regulating use of micro-generation by strict building codes can promote carbon reduction.
Energy neutral housing developments

<table>
<thead>
<tr>
<th>Sub-Instrument</th>
<th>Final Weight</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building code for energy efficiency</td>
<td>0.080</td>
<td>1</td>
</tr>
<tr>
<td>Energy efficiency Obligation for companies</td>
<td>0.078</td>
<td>2</td>
</tr>
<tr>
<td>Renewable Heat Incentive</td>
<td>0.077</td>
<td>3</td>
</tr>
<tr>
<td>Community generation</td>
<td>0.076</td>
<td>4</td>
</tr>
<tr>
<td>Reduced VAT/ stamp duty</td>
<td>0.075</td>
<td>5</td>
</tr>
<tr>
<td>Feed in tariffs</td>
<td>0.068</td>
<td>6</td>
</tr>
<tr>
<td>Micro-gen technology</td>
<td>0.060</td>
<td>7</td>
</tr>
<tr>
<td>Renewable Heat Obligation</td>
<td>0.060</td>
<td>7</td>
</tr>
<tr>
<td>Renewable Heat Incentive</td>
<td>0.056</td>
<td>9</td>
</tr>
<tr>
<td>Building code for carbon reduction &amp; Microgeneration</td>
<td>0.049</td>
<td>10</td>
</tr>
<tr>
<td>Building code for energy efficiency</td>
<td>0.048</td>
<td>11</td>
</tr>
<tr>
<td>Electronic monitoring</td>
<td>0.047</td>
<td>12</td>
</tr>
<tr>
<td>Electronic monitoring</td>
<td>0.047</td>
<td>12</td>
</tr>
<tr>
<td>Collaboration with Manufacturers/Demonstration</td>
<td>0.047</td>
<td>12</td>
</tr>
<tr>
<td>Obligation Energy supplier</td>
<td>0.046</td>
<td>14</td>
</tr>
<tr>
<td>Grid independent</td>
<td>0.041</td>
<td>15</td>
</tr>
<tr>
<td>Obligation for households</td>
<td>0.034</td>
<td>16</td>
</tr>
<tr>
<td>Planning permits</td>
<td>0.031</td>
<td>17</td>
</tr>
<tr>
<td>MCS</td>
<td>0.027</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>1.000</td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Most prioritized instruments for Eindhoven scenario.

- Further the conflicting comparisons from table 8 are made mainly with respect to municipality and rest of the stakeholders, because it is in the interest and power of municipality to plan and regulate energy neutral developments. But the other stakeholders are also important for successful realization of energy neutral housing. Therefore there is a need for the preferences of Municipality & the other stakeholders to complement each other rather than conflict with each other. The survey shows that municipality prefers different instruments for promoting energy neutral housing developments which is quite contrasting to the priorities of other stakeholders. Further the survey also shows that the municipality prefers stricter regulations to be employed and not focussed on providing support through finances and facilitation. These varied interests raise the need for effective communication between stakeholders for successful realization of energy neutral housing projects.

- These varying priorities can be attributed to varying self interest of the stakeholders. These varying preferences can affect the outcome energy neutral housing projects considering their relative lack of prior experience of stakeholders. Thus lack of structured cooperation between stakeholders is one of the problems affecting the Eindhoven municipality’s ambitions to go energy neutral. There is a need for good collaboration between these stakeholders in the planning, development and realization phases. The municipality which is the spearhead for Eindhoven’s energy neutral vision has to take these varied preferences into account while planning for any developments. This is discussed by making a scenario analysis on Blixembosch Noord Oost development in the next chapter.
6 SCENARIO ANALYSIS

6.1 Introduction
The successful role played by the Danish municipalities to foster energy ambitions in housing sector are accounted for in the desk research and the survey results show the prioritized instruments for Eindhoven scenario. To validate these findings for Eindhoven scenario a scenario analysis is conducted on Blixembosch Noord Oost energy neutral development. The role required to be played by Eindhoven municipality in the planning, development & realization phases of the energy neutral developments in order to satisfy the varying preferences of stakeholders and successfully promote their participation in the energy neutral housing developments are found from this scenario analysis.

6.2 Blixembosch Noord Oost energy neutral housing development
By dismantling of the new road junction A50/A58 (Ekkersrijt) an area of about 18 hectares is available for housing. The Eindhoven municipality decided to construct energy neutral homes in this area and granted this land to developers to make it an energy neutral community with approximately 450 homes. This project is part of the "Energie neutral Brainport wonen". Hurks Vastgoed south and Rabo Bouwfonds are the two project developers. The Municipality Eindhoven is the promoter for the development and Brainport Foundation promotes cooperation between companies, knowledge institutions and Municipality (Creative energy, 2009). The objective is to achieve energy-neutral homes with improved living quality and lower monthly costs. All the energy needed for living in the new district will be sustainably generated by facilities in the neighborhood. Therefore, besides an improved comfort also occur lower housing costs, less burden on the environment (less CO2 emissions) and less dependence on rising energy prices. The following energy targets have been set. Epc: 0.55; Carbon reductions: 45% reduction; Renewable energy. The project is still in the planning stage where the final master plan is being developed and the municipality will also sell plots for individual construction.

Figure 9: Blixembosch Noord Oost energy neutral housing development.
6.3 Scenario Development

A scenario approach involves developing future environment situations and describing the path from any given present situation to these future situations. The scenario method has been widely used by decision-makers in business, industry and government for over thirty years as an unrivalled technique to learn about the future before it happens. The type of scenario analysis used here is Global scenario which offers the leaders an outlook into distinctive future environments that have different implications for long-term operating decision and options analysis (John Ratcliffe, 2000). For the current analysis this is appropriate because it is necessary to provide the Eindhoven municipality a futuristic outlook into the possible outcomes due to its long term role playing strategy in realizing Energy neutral housing developments. The different steps involved in the scenario analysis relevant to this research are described:

- **Task identification**: To provide a future vision into the role required to be played by Eindhoven municipality in the planning, implementation & realization phases to successfully realize Blixembosch energy neutral development.
- **Key factors**: All regulatory and support instruments.
- **Driving forces**: Energy efficiency, carbon reduction, renewable energy, financial support, and all stakeholders.
- **Ranking**: The priorities of instruments for different stakeholder groups.
- **Alternatives**: Present scenario & Participatory scenario
- **Scenario development**: Two scenarios are developed in this analysis. The first scenario assumes that in the present Blixembosch Noord Oost development the municipality adopts an existing housing development process. In the second scenario it is assumed that the municipality adopts the role of Danish municipalities for the development process.

The scenarios are developed based on the assumption that, “the role played by the municipality in the planning & regulation, implementation & realization phases, will result in the employment of specific type of instruments which will promote effective stakeholder participation which will determine the outcome of the project”\(^\text{12}\).”

- **Analysis**: The role of the municipality will determine the employment of certain instruments in the planning, development and realization phases of the project. The outcome of the scenario is determined in terms of the closeness of the total priority weights of different stakeholder groups and the total weight of the instruments employed. The closer the priority weights of stakeholder groups are the better is the collaboration between stakeholders and their interests satisfied which means that stakeholder’s participation is effective. The role of municipality indirectly reflects on the type of instruments employed. An instrument if employed or not employed in the scenario is represented by a binary digit (1 or 0). The weights of resulting instruments (Avg. wt) are calculated by taking the average preference weights of the stakeholders (M+P+E+C/4).

\(^{12}\) From the conclusions of chapter 4.
Energy neutral housing developments

### 6.3.1 Present role

This scenario assumes that the municipality promotes its interests, found from the survey, in realizing the energy neutral housing developments. Further the execution of the project is carried out in the existing housing development process. The scenario over view is shown in figure 10. The red boxes imply that municipality has not taken those features into account.

**Role of Municipality:** Since the municipality (M) has awarded the land for development, as a land owner it regulates the project developers to construct energy neutral homes. Further it promotes its preferences i.e. employs strict regulations to be satisfied to implement and realize this housing project. The project developers (P) are responsible for implementing and realizing the ambitions set by municipality. The houses are ready for sale in the realization phase.

**Effects & Resulting Instruments:**

- **Planning:** Municipality played the role as an active landowner and as per it promoted its priorities i.e. strict regulations to ensure successful realization of the project. As a result Low EPC (0.55) requirement, 45% carbon reductions were regulated using building codes and renewable usage was regulated through energy obligations on the prospective house owners and energy suppliers. Further new innovative technology like KWO & Grid independent private wire system was encouraged to be installed. However these project ambitions were not promoted among the citizens.

- **Implementation phase:** Municipality did not participate in the implementation phase and the responsibility was left to the developers. Due to new technical requirements of the project (KWO, higher epc requirements etc.) the developers faced difficulties. They had to consult energy consultants at their own costs. Therefore the developer develops the houses with high initial costs. There was also no customer representation in the development phase. Thus there was no limit on the price of housing.

- **Realization phase:** No participation of municipality in this phase lead to the failure of understanding the need for incentives for customers to satisfy the obligations. Also made customers were reluctant to install microgeneration technologies due to long pay back periods and lack of incentives. High costs of houses also affected prospective

Figure 10: Present scenario.
Energy neutral housing developments

customers. Energy suppliers also did not contribute since there was no demand from consumers The instruments that are employed in this scenario are

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Stakeholder priority</th>
<th>Employed</th>
<th>Avg. wt</th>
<th>Wt. of scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>P</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td><strong>Energy Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building code</td>
<td>0.249</td>
<td>0.105</td>
<td>0.080</td>
<td>0.068</td>
</tr>
<tr>
<td>Obligation energy companies</td>
<td>0.084</td>
<td>0.100</td>
<td>0.065</td>
<td>0.073</td>
</tr>
<tr>
<td>Mandatory E. label/EPC</td>
<td>0.135</td>
<td>0.089</td>
<td>0.040</td>
<td>0.049</td>
</tr>
<tr>
<td>Easements (As landowner)</td>
<td>0.024</td>
<td>0.053</td>
<td>0.034</td>
<td>0.048</td>
</tr>
<tr>
<td>Collaboration Manufacturers</td>
<td>0.050</td>
<td>0.065</td>
<td>0.028</td>
<td>0.045</td>
</tr>
<tr>
<td><strong>Carbon reduction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building code</td>
<td>0.122</td>
<td>0.027</td>
<td>0.044</td>
<td>0.048</td>
</tr>
<tr>
<td>Obligation for households</td>
<td>0.037</td>
<td>0.013</td>
<td>0.017</td>
<td>0.040</td>
</tr>
<tr>
<td>Obligation Energy supplier</td>
<td>0.067</td>
<td>0.037</td>
<td>0.029</td>
<td>0.046</td>
</tr>
<tr>
<td>Planning permits</td>
<td>0.021</td>
<td>0.015</td>
<td>0.013</td>
<td>0.036</td>
</tr>
<tr>
<td>MCS/Model houses</td>
<td>0.013</td>
<td>0.015</td>
<td>0.017</td>
<td>0.028</td>
</tr>
<tr>
<td><strong>Renewable Technology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community gen.</td>
<td>0.008</td>
<td>0.070</td>
<td>0.077</td>
<td>0.080</td>
</tr>
<tr>
<td>Grid independent (Pvt. Wire)</td>
<td>0.070</td>
<td>0.035</td>
<td>0.013</td>
<td>0.053</td>
</tr>
<tr>
<td>Micro-gen technology</td>
<td>0.023</td>
<td>0.032</td>
<td>0.031</td>
<td>0.069</td>
</tr>
<tr>
<td>Electronic monitoring</td>
<td>0.039</td>
<td>0.059</td>
<td>0.025</td>
<td>0.040</td>
</tr>
<tr>
<td><strong>Financial Support</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed in tariffs</td>
<td>0.005</td>
<td>0.051</td>
<td>0.127</td>
<td>0.071</td>
</tr>
<tr>
<td>Domestic green loans</td>
<td>0.033</td>
<td>0.091</td>
<td>0.042</td>
<td>0.056</td>
</tr>
<tr>
<td>Reduced VAT/ stamp duty</td>
<td>0.016</td>
<td>0.050</td>
<td>0.121</td>
<td>0.076</td>
</tr>
<tr>
<td>Ren Heat incentive</td>
<td>0.005</td>
<td>0.090</td>
<td>0.196</td>
<td>0.073</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0.727</td>
<td>0.391</td>
<td>0.288</td>
<td>0.421</td>
</tr>
</tbody>
</table>

Table 10: Resulting instruments for Regulatory role scenario

**Outcome:** Though municipality successfully fulfilled its priorities (0.727) by setting strict regulations, it failed to facilitate these regulations by not providing any support instruments. Further it failed to participate actively in the project after the planning stage and thus there was no communication with the other involved stakeholders. No participation of
municipality in the development and realization phase has led to the neglecting of preferences of the stakeholders.
The lack of representation of consumers in the development phase resulted neglecting of their preferences. Lack of collaboration between developers (0.391) and energy consultants (0.288) lead to unsatisfactory technology solutions. So there was no effective communication between stakeholders at any stage of the project. The short term active role of municipality and non-representation of consumers (0.421) in the development phase has resulted in implementation of unsatisfactory instruments in the project. Lack of municipal participation in realization phase affected the employment of microgeneration technology by consumers since there were no incentives offered. Thus the chances of success for the development of energy neutral community are low in this case represented by the total weight of the scenario (0.457).

6.3.2 Participatory scenario

This scenario is described based on the findings from the role played by Danish municipalities. That is the municipality is involved in all phases of the project and the diverse stakeholders and their interests are engaged together in reaching for a consensus on the planning, implementation and realization of project. The overview of the scenario is shown in Figure 11.

Role of Municipality: The municipality plays a proactive role as a local planning authority and incorporates obligations & regulations on energy neutral housing developments in its local land allocation plans. As a planning authority it has close dialogue with project developers and also promotes the ambitions set to the citizens. It provides technical & financial advice to the project developers. In implementation phase it puts regulations into practice by having a close dialogue & contractual agreements with contractors & developers during the process. It facilitates innovative partnerships between developers & manufacturers. It provides technical support to the developers by involvement energy consultants. It involves customer representatives in development phase to incorporate their preferences in the project. Municipality promotes the existing renewable technology for producing renewable energy. In the realization phase it facilitates prospective house owners’ participation through promotional events. It supports the housing obligation by providing financial incentives.

Resulting instruments: The municipality is closely involved in all of the phases of the design and development of the entire project, including the facilitation of the process in terms of assuring that the involved stakeholders address and comply with the outlined strategies in the area. As a result of its role the following instruments were employed in different project phases.

- **Planning phase:** As a planning authority municipality ensured energy neutral houses were made legally binding for the developers through local plans. To regulate them building code was improved with higher efficiency requirements. Informative role promoted citizens interest in the development.

- **Implementation phase:** Through innovative partnerships the municipalities promoted collaborated between manufacturers and developers in developing the model houses.
Municipality promoted consumer participation through model houses. Municipality facilitated the expert advice of energy consultants to the developers. Further consumer participation in implementation phase helped them choose community generation as it was more attractive in terms of lower investments and lower risks.

Figure 11: Role of municipality in extended role scenario.

- **Realization phase**: Due to complaints of high costs, stamp duty on the dwelling was reduced to provide incentive to the purchasing customers. Municipality encouraged prospective house owners to install microgeneration technologies at home through demonstration & certificate programmes. To support the obligations the municipality promoted attractive financial incentives and the house owners successfully installed microgeneration technology. Due to the involvement of consumers in renewable energy generation, the energy suppliers were willing to provide support, advise and promote their activities.

**Outcome**: For this scenario, the project developers (0.739), and consumers (0.739) have shown their support to the development by achieving almost equal priority weights. The effective representation of consumers in the implementation and realization phases has increased the chances of development to be more feasible. The municipality (0.619) prioritized the preferences of the stakeholder over its own priorities. Energy consultants have the most knowledge about energy neutral concept and their priority weight of (0.823) shows that the Blixembosch Noord Oost community has high chances of being successful. So a long term active role of Municipality promoting collaboration between all stakeholders and a balanced combination of Regulation & support instruments have can result in higher success rate (0.731) for energy neutral developments.
Energy neutral housing developments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Stakeholder priority</th>
<th>Employed</th>
<th>Avg. wt</th>
<th>Wt. of scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>P</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td><strong>Energy Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building code</td>
<td>0.249</td>
<td>0.105</td>
<td>0.080</td>
<td>0.068</td>
</tr>
<tr>
<td>Obligation energy companies</td>
<td>0.084</td>
<td>0.100</td>
<td>0.065</td>
<td>0.073</td>
</tr>
<tr>
<td>Mandatory E. label/EPC</td>
<td>0.135</td>
<td>0.089</td>
<td>0.040</td>
<td>0.049</td>
</tr>
<tr>
<td>Easements</td>
<td>0.024</td>
<td>0.053</td>
<td>0.034</td>
<td>0.048</td>
</tr>
<tr>
<td>Collaboration Manufacturers</td>
<td>0.050</td>
<td>0.065</td>
<td>0.028</td>
<td>0.045</td>
</tr>
<tr>
<td><strong>Carbon reduction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building code</td>
<td>0.122</td>
<td>0.027</td>
<td>0.044</td>
<td>0.048</td>
</tr>
<tr>
<td>Obligation for households</td>
<td>0.037</td>
<td>0.013</td>
<td>0.017</td>
<td>0.040</td>
</tr>
<tr>
<td>Obligation Energy supplier</td>
<td>0.067</td>
<td>0.037</td>
<td>0.029</td>
<td>0.046</td>
</tr>
<tr>
<td>Planning permits</td>
<td>0.021</td>
<td>0.015</td>
<td>0.013</td>
<td>0.036</td>
</tr>
<tr>
<td>MCS/Model houses</td>
<td>0.013</td>
<td>0.015</td>
<td>0.017</td>
<td>0.028</td>
</tr>
<tr>
<td><strong>Renewable Technology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community gen.</td>
<td>0.008</td>
<td>0.070</td>
<td>0.077</td>
<td>0.080</td>
</tr>
<tr>
<td>Grid independent</td>
<td>0.070</td>
<td>0.035</td>
<td>0.013</td>
<td>0.053</td>
</tr>
<tr>
<td>Micro-gen technology</td>
<td>0.023</td>
<td>0.032</td>
<td>0.031</td>
<td>0.069</td>
</tr>
<tr>
<td>Electronic monitoring</td>
<td>0.039</td>
<td>0.059</td>
<td>0.025</td>
<td>0.040</td>
</tr>
<tr>
<td><strong>Financial Support</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed in tariffs</td>
<td>0.005</td>
<td>0.051</td>
<td>0.127</td>
<td>0.071</td>
</tr>
<tr>
<td>Domestic green loans</td>
<td>0.033</td>
<td>0.091</td>
<td>0.042</td>
<td>0.056</td>
</tr>
<tr>
<td>Reduced VAT/ stamp duty</td>
<td>0.016</td>
<td>0.050</td>
<td>0.121</td>
<td>0.076</td>
</tr>
<tr>
<td>Ren Heat incentive</td>
<td>0.005</td>
<td>0.090</td>
<td>0.196</td>
<td>0.073</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0.619</td>
<td>0.739</td>
<td>0.823</td>
<td>0.739</td>
</tr>
</tbody>
</table>

Table 11: Resulting instruments for Participatory role scenario
6.4 Conclusions

The final weight of participatory scenario (0.731) against the final weight of regulatory role (0.457) clearly shows that a long term participatory role of municipality is necessary for the success of energy neutral housing developments.

- In participatory scenario the municipality acted more as a planning authority rather than the property owner. So it could effectively steer energy neutral regulations with more authority using its localized land allocation plans. In participatory scenario the Municipality actively took part in all the phases of the project. It understood the needs and preferences of all stakeholder groups better and thus could was able to support and facilitate the stakeholder. Thus the regulations employed were fulfilled by the stakeholders effectively. This shows that there is a need for the municipality to satisfy the interests of various stakeholders for the success of the project.

- The priorities of municipality were not implemented completely even then the project shows good signs of success. This shows that promoting stakeholder interests should be the main priority for Municipalities in energy neutral developments since such projects are new to the building sector and thus pose great technical and implementation difficulties for stakeholders.

- Adopting the role of Danish municipalities can be advantageous for Eindhoven municipality in development process of Blixembosch development process. The project is currently in its planning phase. This analysis proved that a more participatory and active role of municipality can indeed lead to a successful outcome of the project. The analysis also highlighted the importance of communication between future customers/consumers and municipality.
7. CONCLUSIONS

7.1 Introduction
This chapter contains all the answers to the sub-questions framed in the chapter 1. The answers are based on the conclusions from Desk research conducted on Denmark & UK, survey results and scenario analysis. The main question “What are the successful instruments needed to foster the energy neutral ambitions in the Eindhoven housing sector and what is the role of municipality to realize these ambitions?” is answered in this chapter.

7.2 Research answers

1.1 What are the regulatory & support instruments employed in Denmark & UK?
Desk research showed that Danish regulatory & support instruments are focussed on improving the energy efficiency of households and promoting renewable energy usage in housing sector through community owned cooperative farms. UK on the other hand has employed numerous financial support instruments like renewable heat incentive; LCBP grants, reduced VAT & Stamp duty etc. are available to promote carbon reduction using microgeneration technology and decentralized energy sources. The successful instruments employed in UK & Denmark found through research is shown in table 2 under chapter 4.

1.2 How are the instruments found from UK & Denmark prioritized for Eindhoven scenario?
Eindhoven needs to focus primarily on improving energy efficiency in households using strict building codes and obligations on energy companies. This has to be complemented with strong financial support in terms of feed in tariffs and VAT reduction on energy efficient measures for consumers. Further community owned renewable energy generation should be prioritized for new housing communities. Stakeholders believe promoting use of micro-generation by providing green loans attached to properties and renewable heat incentives can lead to carbon reduction. The prioritized instruments for Eindhoven scenario are listed in table 9 of chapter 5.

1.3 How can these instruments be adopted for Eindhoven scenario?
The successful instruments found from research are focussed on promoting energy efficient & carbon neutral housing developments. For promoting energy neutral developments in Eindhoven a combination of these instruments is necessary. Though some of these instruments exist, there is still a need to strengthen or widen their scope to promote energy neutral housing developments effectively. It is interesting to see how Eindhoven can learn to adopt these instruments using Denmark & UK experiences. Based on the findings and the personal knowledge gained from research, need to be adopt / improve some prioritized instruments to successfully achieve energy neutral housing developments are shown in the table below. The conclusions from survey analysis prove that it is important to promote the interests of local businesses & stakeholders involved in housing developments over the self interests of the municipality. Thus the municipality has the responsibility to facilitate these interests using the recommended regulatory & support instruments.
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Present situation</th>
<th>Denmark/UK</th>
<th>Implementation/Improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building code for energy efficiency</td>
<td>With energy neutral ambitions by 2020, currently an epc of 0.8 (100kwh/m2) is mandatory. There is still no definition for low/zero energy buildings in Netherlands</td>
<td>Denmark has a minimum requirement of 85kwh/m2 at present with energy ambition of 75% reduction by 2020. UK has a separate sustainable building code focused on carbon neutral buildings.</td>
<td>With the Eindhoven energy neutral ambition the current requirement needs to be lower than epc 0.8. There is a need for stricter building code with strict definitions for energy neutral houses/buildings.</td>
</tr>
<tr>
<td>Energy obligations for companies</td>
<td>Currently focussed on transport sector only 13</td>
<td>Energy targets for companies have raised some difficulties in the scope of employment.</td>
<td>Need to learn from the drawbacks of Danish obligations.</td>
</tr>
<tr>
<td>Renewable Heat incentive</td>
<td>Grants 16 are available, but only for houses built before 2008 under “Subsidieregeling Duurzame warmte”</td>
<td>UK has introduced renewable heat incentive i.e. grants for purchasing renewable heat sources for new and existing households.</td>
<td>Need to extend RHI to newly constructed houses to encourage installation of more renewable heat sources in the new developments.</td>
</tr>
<tr>
<td>Community owned energy cooperatives</td>
<td>Though some examples 15 exist in Netherlands the concept is still not promoted well.</td>
<td>In Denmark wind farms and solar farms owned by community members (cooperatives) supply majority of renewable energy.</td>
<td>Need to develop Community owned renewable generation concept on the successful lines of Denmark. Danish share based investment model 16 can ensure large scale energy generation with low investments for house owner.</td>
</tr>
<tr>
<td>Reduced VAT/Stamp duty</td>
<td>Reduced VAT (6%) on certain energy efficient renovation material only. No stamp duty exemption is possible.</td>
<td>UK has fixed only 5% VAT on purchase of all micro generation technologies used in households. UK has exempted stamp duty for carbon neutral homes worth less than 500,000 pounds</td>
<td>Need to extend VAT exemption for new houses and also micro generation technology to promote renewable energy. Exemption of stamp duty on energy neutral houses can be attractive incentive for customers.</td>
</tr>
<tr>
<td>Feed in Tariff &amp; Micro- generation technology</td>
<td>There are still no clear FIT rules for household producers.</td>
<td>UK FIT is designed to benefit household owners though generation and Export tariff.</td>
<td>Need to implement FIT to promote microgeneration which indirectly promotes renewable energy and carbon reduction.</td>
</tr>
<tr>
<td>Domestic green loans</td>
<td>Low interest loans are available for purchasing green technology and energy efficient</td>
<td>UK offers green loans fixed to the property rather than the users.</td>
<td>Need to also fix loans for properties rather than individuals to ensure that individuals don’t have to think of payback period</td>
</tr>
</tbody>
</table>

---

13 SenterNovem
14 SenterNovem: wijzigen subsidieregels voor zone boilers en lucht waterwarmtepompen
15 Veenendaal Oost: No consumers involved, owned by joint cooperation between, Municipality, Housing corporation and project developer
16 Appendix I
Energy neutral housing developments

<table>
<thead>
<tr>
<th></th>
<th>renovation.</th>
<th>for their investments.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easements</td>
<td>No strict enforcement exists to regulate land buyers to build energy neutral buildings.</td>
<td>Denmark has successfully reformed its Planning Act and the Building Regulation in 2006 to employ this regulation in its local plan. The municipality should make energy neutral requirements mandatory in its land allocation plans when the next revision of local planning comes. This will legally regulate the private developers to build energy neutral houses.</td>
</tr>
<tr>
<td>Collaboration with manufacturers</td>
<td>Energy neutral housing development projects are quite expensive and Developers don’t have good knowledge of the latest technology.</td>
<td>In Denmark energy efficient renovation/construction projects have collaborated with material manufacturers like Velux, Rockwool &amp; Danfoss. They provide technology assistance, expertise and also costs of construction / renovation can be reduced. They can also market the projects better as it also helps for their advertising.</td>
</tr>
<tr>
<td>Grid Independent (Private wire)</td>
<td>Policies don’t grant the freedom to employ private wires.</td>
<td>Woking borough council and Poundbury have implemented private wires and supply electricity at reduced tariffs. Allows sale of electricity without distribution charges. Perfectly suitable for degeneration of renewable energy.</td>
</tr>
<tr>
<td>EPC</td>
<td>Initially failed implementation due to improper organization.</td>
<td>The laws have made it impossible to get a house without an EPC. EPC implementation strategy is now modified, but still needs to be well promoted, for example reducing the costs for getting the epc.</td>
</tr>
<tr>
<td>Domestic green loans</td>
<td>Long pay back periods of green loans restrict house owners to stay in the same house over long duration. So they are unwilling to obtain such loans.</td>
<td>In UK tied Loans are tied to properties rather than individuals. Loans attached to the properties rather than individuals are beneficial, so that if a family move before payback on the loan, then the next occupants will be responsible for the repayments. Further Obligations on households to generate renewable energy will confront the new occupants to accept the repayment terms.</td>
</tr>
</tbody>
</table>

Table 12: Implementing the prioritized instruments for Eindhoven scenario

2.1 What is the role played by the Danish municipalities in successfully realizing energy efficient housing developments?

Danish municipalities have realized the energy efficient projects by playing a proactive role. They have taken an active part in all the phases of the project and successfully promoted stakeholder participation. They have satisfied the interests of different stakeholders by playing a participatory role i.e. the diverse stakeholders and their interests are engaged together in reaching for a consensus on a plan and its implementation. The highlights of the role played by the Danish municipalities are shown under the conclusions of chapter 4.

---

17 Land allocation plans are legally required to be changed every 10 years (Chapter 2, role of municipalities)
18 Nyenrode University, 2010.
Energy neutral housing developments

2.2 What is the role required to be adopted by Eindhoven municipality to promote stakeholder participation in energy neutral housing developments?

The outcome of the scenarios clearly shows that an active participation of municipality in all the phases of the project is necessary to ensure success in energy neutral development projects. This extended role constitutes various responsibilities needed to be fulfilled by the municipality in these phases of the project.

3.1 What instruments can be implemented to ensure consumers to invest in energy neutral measures for achieving Blixembosch energy neutral housing development?

A scenario analysis on the Blixembosch Noord Development has resulted in understanding the current progress of project. The research has provided insights into how various support instruments are employed to facilitate practical realization of energy neutral housing developments. Using these experiences the following suggestion is presented for the promoters of the project.

To involve the consumers financially in energy neutral development projects, it is important to first market the concept of energy neutrality in terms of monetary benefits. To market the concept of energy neutrality, there is a need for involving the consumers more effectively in the road to energy neutral housing. This statement can be supported by the scenario analysis which shows that promoting effective participation of consumers in planning, development & realization phases of neutral energy developments can lead to favorable outcomes (0.831). From the conclusions on scenario analysis and excerpts from the research certain ways to involve consumers in energy neutral developments are found.

- **Model houses**: Through the concept of Model houses in Albertslund municipality, Denmark has highly motivated consumers to support energy efficiency in housing renovation. From the research survey it shows that project developers and consumers have high interest in the concept of collaborating with manufacturers to promote energy concepts through demonstration houses.

  **Concept**: The Model houses are used as an interaction tool between the project developers and consumers. The consumers are able to see the advantages of adopting energy saving measures and can provide feedback to the developers. Based on the feedback the developer can facilitate necessary changes in the design and as a result the consumer is more willing to invest in the house. This in combination with “Collectief Particulier Opdrachtgeverschap19” (CPO) is ideal, as the consumer will spend his own money for the realization of his energy neutral house.

  **Costs involved**: The project developer can reduce his costs to set up demonstration houses by collaborating with manufacturers as in the case of Albertslund municipality. Supporting consumers with exemption of stamp duty as in case of UK will favor their investments and participation in the energy neutral housing developments. Further through “Collectief Particulier Opdrachtgeverschap” the consumer is also able to realize the house for cheaper costs.

---

19 Currently employed for citizen participation in Blixembosch Noord Oost.
Energy neutral housing developments

*Risks:* Lack of manufacturer cooperation makes this concept less feasible. Lack of financial incentives (reduced Stamp duty, RHI etc) may discourage consumer investments.

- **Community owned cooperatives:** The consumers can be attracted to invest in energy neutral community by promoting community based cooperatives which are an attractive investment opportunity. In Denmark, the energy farms owned by these cooperatives have successfully promoted generation of renewable energy with the consumers’ investments. The survey and scenario analysis shows that community based generation is the most preferred by stakeholders including consumers for Eindhoven scenario.

*Concept:* The research shows a case study\(^{20}\) on wind farms in Denmark. Prospective house owners (consumers) of a community can form a cooperative and invest in a farm with solar cell or solar collectors in case of Eindhoven. The initial investments are made on share basis where each share represents a certain amount of electricity/energy generated. Based on the share value and generation capacity the consumer can profit by selling excess energy back to the grid. The farm can be maintained by an energy company. Thus the consumer is profited from his investment and at the same time the concept of energy neutral is promoted.

*Costs involved:* Initial investments by the consumer should be supported by green loans at cheaper rates. Attractive feed in tariffs can increase returns and further encourage the participation of end consumers.

*Risks:* The profits for the consumers are dependent on the energy generated from the farm. Lack of availability of loans at cheaper rates can discourage the consumers. Since the cooperative is run by the consumers themselves, there is a need for strict transparent administration.

- **What are the successful instruments needed to foster the energy neutral ambitions in the Eindhoven housing sector and what is the role of municipality to realize these ambitions?**

Strict building codes, energy obligations on households, community generation, incentives to promote renewable energy using microgeneration and an important role of municipality to promote the instruments using local plans and effective participation in all phases of developments are important for promoting energy neutral ambitions of Eindhoven. Further good representation of consumers has been highlighted from the scenario analysis & Denmark’s example. This conclusion is validated by the fact that even Blixembosch Noord Oost has implemented “Collectief Particulier Opdrachtgeverschap“ to promote customer representation in development process.

\(^{20}\) Appendix I.
Energy neutral housing developments

Not all instruments found from the research on UK & Denmark are successful. For example National level policies of energy obligations for companies and Building energy labels in Denmark’s experience have posed certain difficulties and shown no effect on the improving energy efficiency respectively. RHI in UK has not yet been proved to have a successful impact.

Based on the findings and the scenario analysis the following role is required to be played by municipality in energy neutral developments is shown in the figure below.

Figure 12: Role required to be played by Eindhoven municipality
8. RECOMMENDATIONS & DISCUSSION

8.1 Recommendations
The personal ideas and knowledge gained from the experience of energy efficient/carbon neutral/energy neutral housing developments are presented as recommendations. These recommendations are aimed at contributing towards fostering Eindhoven’s energy neutral housing ambitions, showing the need for further research in the same field and to guide the students by providing possible future research topics.

To foster Eindhoven’s ambitions
- It is recommended to implement financial subsidies and incentives on the lines of UK experiences like FIT’s, property based loans, stamp duty reduction since they target quick profits for the consumers.
- Financial incentives are available currently to install microgeneration technology & energy efficiency measure in existing houses. Municipality should consider extending the financial incentives for installing microgeneration technology and energy efficiency measures for new houses also.
- Municipality should promote energy neutral ambitions through its localized land allocation plans as it has proved to be more effective in case of Danish municipalities. This way the municipalities can employ regulations over all the future developments and not just in the developments happening on the land offered by it.
- For community owned generation it is recommended that Eindhoven municipality should learn from the Danish wind cooperatives established on share basis investments.

Research to fill in current gaps
- The instruments recommended for Eindhoven scenario are only evaluated based on the preferences of the surveyed stakeholder groups. It would be interesting to evaluate these instruments in terms of political, social and financial feasibility.
- Very little information was available on Blixembosch Noord Oost development since it is still in drafting master plan stage. So validation of instruments was done with some assumptions. In future when more information on the planned implementation process is available, it is recommended to validate the findings in a more effective manner.

Scope for future research
- The instruments and the role of municipality are discussed in relation to only private energy housing developments. The same research can be carried out in case of social housing or housing renovation projects where the constraints are different, for example cost of housing has to be very low, new stakeholders like housing associations are present etc.
- The role of municipalities of UK was not researched due to lack of sufficient available information and lack of time to make site visits. To avoid this in future a detailed research on finding more successful municipal roles/local practices should be done by spending more time in the relevant countries.
Energy neutral housing developments

- UK is now developing an ESCO model for promoting energy companies to invest in energy ambitions of housing sector. A small overview of such model is presented in appendix II. Future research can concentrate on implementing such models in Netherlands.

8.2 Discussion

- The information available in relation to Netherlands and Eindhoven was completely in Dutch. So inability to read Dutch has affected me personally in understanding the current developments in regulatory policies, planning and project development process. This is the major backdrop of this research which otherwise would have been more reflective on the current developments.

- The instruments found from Denmark & UK experiences are adopted for only energy efficient and carbon neutral housing developments. This research presumes that a combination of these instruments will equally promote the energy neutral developments. This can lead to conflicting views, but in my perspective it is valid since the energy efficiency and carbon neutral are integral features of energy neutral housing concept. Therefore the developments in these fields will indirectly influence energy neutral developments.

- According to Hsin-Pin Fu et al, 2009 energy projects are evaluated in project performance by using the equal weights of performance criteria and most studies do not consider the importance degree of performance criteria. For the scope of this research the successful instruments have been assumed as the performance criteria for and the successful outcome of energy neutral developments is dependent on them. However there exist performance criteria for technical, financial, governance and other aspects related to energy neutral developments which should also be taken into account.

- This research aims at finding a practical approach for realizing Energy neutral housing developments. Therefore the relevant background literature and information on desk research was collected from reports, internet articles and case studies. This approach suits the research since the aim is to learn from the experiences of the European Union.
Energy neutral housing developments

BIBLIOGRAPHY

Articles
12. Hsin-Pin Fu et al, (2009); Using AHP to analyze the priority of performance criteria in national energy projects.
Energy neutral housing developments

33. Sunikka M & Boon C. (2002); Environmental policies and efforts in social housing: the Netherlands. Building Research and Information 30(6).
Energy neutral housing developments

35. Togeby et al., (2009), Danish energy efficiency policy: revisited and future improvements
36. Williams, J. (2009), The deployment of decentralized energy systems as part of the housing growth programme in the UK. Energy policy.

Reports
1. Bauke de Vries (2008), Quickscan energiezuinige wijken in Nederland, Saxion Hogescholen.
2. Blair Hamilton (2010), A Comparison of Energy Efficiency Programmes for Existing Homes in Eleven Countries, Department of Energy and Climate Change, UK.
3. CONCERTO (2009), Class 1 Cost-effective Low-energy Advanced Sustainable Solutions
8. ECEEE (2009), European council for an energy efficient economy; net zero energy buildings: definition issues and experience, September 2009.
Energy neutral housing developments


Internet pages

1. Creative energy, 2009, Op Weg Naar Energieneutraal,
3. Energy efficiency, 2006, European Commission energy
4. Energiesubsidiewijzer, Meer Met Minder energie
5. Energy Saving Trust, 2005
6. Energy saving trust, UK
10. Green tax package,1995,
12. Kolding municipality, 2009, Climate change & innovation in building sector,
13. MCS, 2006, Department of Energy & Climate change.
16. Roskilde Universitet, 2009, Naestved: sustainable construction and climate strategy,
17. RHI, 2010; Department of Energy & Climate change,
APPENDIX

I. CASE STUDY: DANISH WIND COOPERATIVES

The high acceptance of wind turbines in Denmark is due to a large extent to the fact that the majority of the Danish turbines are owned by private households based on neighborhood co-operatives. About 150,000 Danish households were registered as owners of shares in wind turbines in 2001. (Source: Danish energy policy.pdf, Denmark folder)

Private individuals and cooperatives have played an important role in the development of the Danish wind energy sector. On a rough estimate, approx. 15 per cent of the Danish wind turbines today are owned by cooperatives. Further the new legislation from January 2009 is aimed at stimulating the local engagement and ownership in new wind energy projects. The new Danish act on renewable energy imposes an obligation on all new wind energy projects to offer minimum 20 per cent ownership to local people i.e. cooperatives.

- **How they are formed:** Wind turbine cooperatives in Denmark are normally partnerships, which in daily practice function as cooperatives. But for legal reasons they are forced to establish formal partnerships due to the fact that in Denmark the interest on the loan for the wind turbine is tax deductible from the private income of the individuals in a partnership, not in a cooperative. A cooperative is generally formed with a group of interested individuals who provide the investments and Utility which provides the technical support.

- **Financing of the cooperative:** A cooperative consists of shares where each partner (shareholder) in the cooperative owns a part of the wind turbine corresponding to the number of shares bought by him respectively. (Source: Cooperatives, 2009) Often one share is calculated corresponding to the yearly production of 1000 kWh from that particular wind turbine. The total number of shares is dependent on the capacity of the wind farm. All shares have to be paid up front in order to follow the constitution of the cooperative. (Gunnar Boye Olesen and Judit Szoleczky, 2003)

The individuals can get 100% finance with a bank loan for purchasing the shares in the cooperative. These shares will be considered collateral by the bank and the loan term is dependent on the project’s payback. For, example a project with a 11 year payback qualifies for a 11-year loan. The bank takes all income until the loan is recovered. (Paul gipe, 1996)

- **Economics:** The revenues of individuals in a cooperative are tax exempt if the investment is less than their own electricity consumption plus 50%. For a typical Danish household consuming 6,000 kWh/yr, they can buy shares equivalent to 9,000 kWh/yr. Investments beyond this limit are not tax exempted. The utility pays the cooperative for the total wind generation.

---

21 Lessons for Russia from Denmark
• **Organization:** The Danish wind cooperatives use the form of interest society incorporation where the shareholders are liable for the cooperative's debts. Shares must be sold when people relocate outside the permitted zone or the shares lose their tax-exempt status. Most cooperatives get a contract from the utility for the life of the project or 20 years.

• **Incentives:** Revenues from a cooperative investment in Denmark are tax exempt. With a tax rate of about 50%, this is an extremely attractive incentive and is the driving force for cooperative investments. The revenue from a family's investment in a wind turbine cooperative is tax exempt if the wind turbines are located within their own commune or an adjoining commune. Revenues are tax exempt if the investment is less than their own electricity consumption plus 50% i.e. for a house with electricity consumption of 6000 kwh/yr the owner can buy shares worth 9000 kwh/yr.

Danish government provides the tax exemption to encourage individual action toward meeting Danish energy and environmental policy. Through this program nearly any Danish household can effectively generate all their own electricity with wind energy. Though support for wind energy and support of individual access to wind energy is not universal in the Danish government, there is an influential green coalition of several political parties. (Source: Paul gipe, 1996)

• **Legal aspects:** There are legal concerns while setting up wind turbines mainly regarding the density of turbines, distance from houses, noise levels and aesthetic concerns. Even though there is also no simple rule to indicate the optimum density of wind turbines when taking environmental concerns of the population the Danish experience seems to indicate that it depends on both the type and the size of turbines, the organization of ownership and the rate of penetration. (Source: Danish energy policy.pdf, Denmark folder)

Denmark with a population density of 120/km² corresponds to an average of one turbine/7.7km². Further in municipalities with higher densities this average comes down to one turbine/3.3.

• **Revenue model:** The revenue model for an individual in a cooperative can be best discussed by sighting an example from the world’s largest cooperatively owned wind farm with more than 8000 members namely The Middelgrunden Offshore Wind Farm (40 MW). It was developed though cooperation between the municipality, an energy company and a number of private individuals. The Co-operatives part consists of 40,500 shares (10 x 2 MW turbines). The budget of the Co-operative is 172 million DKK22 (app. 50% of the total budget). One share yields 1000 kWh/year and is sold for 4250 DKK.

---

22 DKK=0.134Euro (May, 2010)
<table>
<thead>
<tr>
<th>Actions</th>
<th>Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selling Price of Electricity</td>
<td>330 DKK</td>
</tr>
<tr>
<td>RE certificate</td>
<td>270 DKK</td>
</tr>
<tr>
<td>Income/year</td>
<td>600 DKK</td>
</tr>
<tr>
<td>Maintenance cost</td>
<td>-70 DKK</td>
</tr>
<tr>
<td>Net income/year</td>
<td>530 DKK</td>
</tr>
<tr>
<td>Rate 530/4250</td>
<td>12.5%</td>
</tr>
<tr>
<td>Simple payback time</td>
<td>8 years</td>
</tr>
<tr>
<td>Calculated lifetime</td>
<td>20 years</td>
</tr>
<tr>
<td>5% yearly depreciation</td>
<td>212.5 DKK/year</td>
</tr>
<tr>
<td>Income after depreciation</td>
<td>317.5 DKK/year</td>
</tr>
<tr>
<td>Rate after depreciation 317.5/4250</td>
<td>7.5%</td>
</tr>
</tbody>
</table>

Table i: Revenue model of Middelgrunden community wind farm
II. CASE STUDY: ESCO IN WOKING MUNICIPALITY, UK

Since 1991, the London Borough of Woking has installed over 60 independent reciprocating engine CHP machines across the borough. Each machine is connected together by a private wire network owned by the energy services company, Thameswey Energy Ltd, which is 100% owned by the borough. Renewable sources such as photovoltaics are also included into the network. By 2003 the borough was 99.85% off of the national grid. From 1991 to 2002 Woking has reduced energy consumption by 43.8% (170,170,665 kWh) and cut carbon emissions by 71.5% (96,588 tones). Total savings for the Borough in 11 years have amounted to £4.9 million pounds.

Woking invested the profits in renewable energy projects, and by 2004 had installed 10% of the UK’s solar photovoltaic (PV) capacity and the UK’s first fuel-cell combined heat and power (CHP) system (200 kWe). It has a network of 60 local generators, including CHP to heat and cool municipal buildings, social housing and town-centre businesses. The key to the Council’s success is the combination of technical innovation (such as CHP, absorption cooling, private wire systems etc.) partnership with the private sector; financial/commercial innovation; and, the use of a local electricity balancing and trading system. (Source: Beacon case study – sustainable energy, 2005)

**Organization:** Thameswey limited was set up by, and is wholly owned by, Woking Borough Council. It was established in February 1999. TW has entered into an agreement with Woking Borough Council to act in an environmentally friendly way as its contractor to invest in CHP Plants to sell heat. In July 1999, TW invested in its joint venture company Thameswey Energy Limited that brought together the council with a Danish company called Xergi limited. This partnership allowed the council to finance the first CHP energy station in Woking town centre.

The use of the Thameswey Joint Venture Projects has allowed the council to escape capital controls that would be imposed on a purely local government venture. This means they can implement large scale projects, primarily with private finance with the council’s shareholding capital coming from the council’s energy efficiency recycled fund, which in itself is recycled with each Thameswey project.

**Technology:** Borough council is meeting all the energy demands with a combination of Solar PV’s and CHP. A fuel cell CHP system is in use, which is the first of its type in UK (Source: installations in Woking). It has pioneered the development of a network of over 60 local generators, including cogeneration and tri-generation plant, photovoltaic arrays and a hydrogen fuel cell station, to power, heat and cool municipal buildings and social housing. Many town centre businesses are also connected to this local energy supply. (Source: 7468)
**Private wire:** Private wire enables green electricity to be sold directly to customers rather than exporting the electricity to the grid and incurring unnecessary use of systems and losses charges since under the laws of physics electricity will always flow the nearest load, i.e., the local community. Woking is unique in that it is the only local authority in the UK to supply electricity as well as heat to local residents on its CHP/renewable energy private wire sustainable energy networks.

![Diagram of corporate structure of Thameswey](image)

**Figure i:** The corporate structure of Thameswey.

**Financing:** Thameswey’s commercial activities provide revenue for the Council to reinvest in energy efficiency, renewable energy and tackle fuel poverty within Woking. The Thameswey model provides financing for projects such as housing stock improvements, large scale public solar PV and heating system retrofits for low income families. This long term capacity to reinvest in emissions reduction has been the key to for council’s achievement in reducing such high percentage of carbon emissions.
III. QUESTIONNAIRE INFORMATION

This information was provided to the participants who took part in the online survey. This information was provided to give a brief idea of the instruments which are put to survey.

Research background: This questionnaire has been structured to validate my research for my current graduation topic “Instruments for successful Energy neutral housing developments – Lessons for Eindhoven from Danish & UK housing sector”. Denmark & UK are focusing on high energy efficiency in buildings and reducing carbon emissions by using micro generation technologies respectively. For scope of my research I have studied these instruments through literature research and found that a combination of these aspects is necessary for achieving Eindhoven’s energy neutral ambitions.

Questionnaire: The following Instruments (criteria) found through my literature research are being employed currently in Denmark & the UK. The questionnaire is only aimed at knowing which of the following criteria can be used to achieve energy neutrality in Eindhoven households. Your experience and knowledge on energy neutral/low energy/ carbon neutral/ renewable energy/ backgrounds will be helpful in answering the questionnaire.

I REQUEST ALL THE SURVEYORS TO READ/KEEP THIS DOCUMENT WHILE ANSWERING THE QUESTIONNAIRE

GOAL
SUCCESSFUL INSTRUMENTS FOR ENERGY NEUTRAL HOUSING IN EINDHOVEN

CRITERIA
ENERGY EFFICIENCY
CARBON REDUCTION & MICROGENERATION
RENEWABLE ENERGY TECHNOLOGY
FINANCIAL SUPPORT

SUB-CRITERIA: Given below (R) - Regulations; (S) – Support
**Energy efficiency**: The following instruments are all aimed to regulate and facilitate the reduction of energy consumption in households. EU has passed EPBD\(^23\) which asks its member nations to impose strict regulations to decrease their energy dependence on fossil fuels. Denmark & UK have implemented these instruments in order decrease the energy consumption (kwh/m²) in households.

<table>
<thead>
<tr>
<th>Stricter building codes (R):</th>
<th>Building codes have enforced strict energy consumption limits for new housing developments. This is aimed to increase the energy efficiency of households.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy efficiency obligations for energy companies (R):</td>
<td>Energy companies have an obligation to reduce energy consumption in households by providing advice, energy audits, subsidies etc. For example; reduction targets have been set as 2.95 PJ(^{24}) (0.7% of total energy usage) for 2006-09 in Denmark.</td>
</tr>
<tr>
<td>Mandatory energy labeling/EPC(^25) (R):</td>
<td>Energy labeling and EPC are used to label a house based on its energy efficiency. These labels are generally from A-G, where A means most efficient and G means no efficiency at all.</td>
</tr>
<tr>
<td>Easements (R):</td>
<td>Easements are a process where municipality can impose legal regulation on the land owned it. It can make energy performance requirements lawfully binding (compulsory) for those buying and building on that land. So the buyers are legally obliged to build low energy/energy neutral buildings on that land. This Instrument is backed/ supported by a planning &amp; building regulation act in Denmark.</td>
</tr>
<tr>
<td>Collaboration with material manufacturers (s)/demonstration houses:</td>
<td>Project developers and municipalities are making collaborations (contracts) with material manufacturers for building demonstration houses. The developers are trying to showcase customers the latest technology that can be used in houses to increase energy efficiency or make low energy houses. So they have made contracts with material and appliance manufacturers to supply these new technologies for low cost. This guarantees very low material/technology costs for developers and also acts as a promotional activity for manufacturers. Ex: Velux and Rockwool (manufacturers) have such contracts for few projects in Denmark.</td>
</tr>
</tbody>
</table>

\(^{23}\) Energy performance building directive  
\(^{24}\) PJ-Petajoules=10\(^15\) Joules.  
\(^{25}\) An Energy Performance Certificate for a building gives the building an asset rating based on its energy efficiency, which is the performance of building based on the efficiency of construction materials used. It doesn’t take into account the everyday living quality by the occupiers.
Carbon reduction & Micro generation: Renewable energy sources have been found to be the most efficient way to reduce carbon emissions in energy production. UK has employed several regulatory and support instruments and at the same time a Microgeneration approach to curb its carbon emission and go carbon free from 2020. Microgeneration means the small-scale production of heat and/or electricity (generation of a capacity of less than 50 kW) from a low- carbon source. These sources are very close to the final consumption points (households), generally on roof-tops or backyard, in order to reduce the losses from energy transfer.

<table>
<thead>
<tr>
<th>Stricter building codes (R):</th>
<th>The Building Code for sustainable buildings in UK makes it mandatory to use decentralized/micro generation technology for building zero carbon/low energy buildings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obligations for Households (R):</td>
<td>Housing communities are required to generate electricity from onsite renewable. Merton rule in UK has set 10% renewable generation obligation for developments larger than 1000m2.</td>
</tr>
<tr>
<td>Obligations for Energy suppliers (R):</td>
<td>Obligations for energy suppliers to reduce carbon emissions. Ex: UK’s Carbon emission reduction target (CERT) requires energy suppliers to reduce carbon emissions in households by providing subsidies for energy saving measures for consumers.</td>
</tr>
<tr>
<td>Eased out planning permits (S):</td>
<td>Strict planning/building regulations normally required for installing domestic microgeneration technologies in households are removed. Under certain fixed conditions there is no need to get permission for installations. This has avoided the planning costs for owners and thus indirectly increased the installations.</td>
</tr>
<tr>
<td>Micro-generation certificate scheme &amp; (S):</td>
<td>Assurance of quality and service is provided to consumers by certifying the installers and products through a certificate scheme supported by national commission. Currently in use in UK.</td>
</tr>
</tbody>
</table>
Renewable energy technology: Technology to encourage the generation of energy from renewable sources. New forms of energy generation from renewable sources using different technologies are observed in Denmark & UK. These have been highly effective and have proven their worth in terms of money and technology.

| Community owned energy generation: | Decentralized Renewable energy generation in a community by forming cooperatives like wind cooperatives and district heating plants as in case of Denmark. Potential for large scale generation is high due to large combined investments from community and low liability for each individual of community. |
| Grid independent: | In case of onsite renewable generation using Private wire, electricity can be sold directly to customers rather than exporting the electricity to the grid and then back to customers. A private wire system simply connects the generation plant located on site into the existing on site electricity network. Thus it avoids unnecessary distribution charges and energy losses. Thus green electricity can be supplied at a cheaper price. |
| Micro generation technology: | The small-scale production of heat and/or electricity (generation of a capacity of less than 50 kW) from a low- carbon sources using technologies like solar collectors, photovoltaic cells, micro-wind, micro-hydro, heat pumps, biomass, micro combined heat and power (micro CHP) and small-scale fuel cells. |
| Electronic energy monitoring systems & SMART meters: | Electronic energy monitoring system, where one person with a PC can monitor and control the energy consumption in all buildings. Smart meters have a visual display allowing customers to see exactly how much electricity and gas they are using and relay the data to energy firms automatically. |
**Financial support**: It means support in terms of monetary benefits for the households (consumers) to adopt energy saving, carbon reducing and microgeneration techniques. Modified and newly targeted financial schemes that have encouraged households to generate renewable energy and improve energy efficiency are discussed in this section.

<table>
<thead>
<tr>
<th>Feed in tariffs:</th>
<th>FIT with a constant tariff system for producer for a period of 20-25 years is currently followed in UK. The benefits from feed in tariff for an average household using 4500kwh/year with 2.5 kW of solar PV have been calculated as £830.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Green loans:</td>
<td>Green Loans attached to properties rather than individual. In UK if a family moves from the property before payback on the loan, then the next occupants will be responsible for the repayments (as they also enjoy the benefits). So more families are willing to utilize the loans for renovation and micro generation technologies</td>
</tr>
<tr>
<td>Reduced VAT &amp; Stamp duty exemption:</td>
<td>In UK, VAT on All micro-generation technologies used in households has been reduced from 17.5% to 5% and stamp duty for Zero carbon houses below £ 500.000 is exempted.</td>
</tr>
<tr>
<td>Renewable Heat incentive:</td>
<td>In UK, the Renewable Heat Incentive (RHI) will provide financial support for a range of technologies, including air and ground-source heat pumps (and other geothermal energy), solar thermal, biomass boilers etc for new households.</td>
</tr>
</tbody>
</table>
IV. QUESTIONNAIRE
The questionnaire used for survey was developed online using Google documents. Therefore the online questionnaire can be accessed at https://spreadsheets.google.com/viewform?formkey=dGpsVVM3bE9CSjNTVnRqeHpzaE1YdEE6MQ
INSTRUMENTS FOR SUCCESSFUL ENERGY NEUTRAL HOUSING DEVELOPMENTS
Lessons for Eindhoven from the Danish and UK municipalities

Construction Management and Urban Development 2009-2010
S.S.R. Kadarpeta

Graduation program
Construction Management and Urban Development 2009-2010
Process Engineering

Graduation committee
Prof. dr. ir. Bauke de Vries
Dr. Qi Han

Date of graduation
09th September 2010

ABSTRACT
At the local level Eindhoven Municipality has set its ambition to go energy neutral in housing sector by 2020 and decided to develop new energy neutral housing areas. Lack of strict regulations and appropriate forms of support aimed at relevant stakeholders involve has attributed to the lack of acceptance for energy neutral housing in the housing market. Further lack of a defined role for municipality to promote stakeholder participation has affected the realization of energy neutral housing developments. Desk research shows that Denmark & UK have introduced effective regulatory & support instruments to promote their energy ambitions in housing sector. Danish municipalities have played a unique role to promote stakeholder participation in energy efficient housing developments. The instruments found are prioritized for Eindhoven scenario as per stakeholder preferences using Analytical Hierarchy process. Using scenario analysis a proactive participatory role is found necessary for the Eindhoven municipality to promote stakeholder participation in energy neutral housing development process.

Key words: Energy Neutral Housing, Support & Regulation Instruments, Role of Municipalities, Analytical Hierarchy Process, Scenario analysis

INTRODUCTION
The European Union, under the Kyoto protocol, has set ambitious targets for greenhouse gas emissions reduction in order to limit the rising global temperature. At the same time, the EU has adopted equally ambitious targets for its future energy supply. It aims to meet these targets through a range of policy instruments at the Union, Member State and even
sub national level. (Christoph Böhringer et al, 2009). To foster the speed of developments to reach the 2020 targets EU has adopted certain policies and legislations aimed at the three energy targets Carbon emissions, energy efficiency and renewable energy sources.

In European Union buildings account for 40 % of the energy demand and about one thirds of green house gases of which about two-thirds are attributed to residential and one-third to commercial buildings (EC Green paper, 2000). The households represent 63% of total energy consumption of the buildings sector. Electricity consumption in the household sector has grown by 12.5% since 2000 (Enerdata, 2007). Further households energy demand is expected to increase by 0.6% per annum between 2000 and 2030. This is attributed to the growing number of households, around 40 million, in this time period.

Member states, as per the EU regulations on Carbon emissions, renewable energy sources and energy efficiency, have outlined their own energy ambitions for year 2020 and set them as national level targets. The energy ambitions are spread over three layers of governance as observed in EU member states namely the Central government, Regional government and Local government (municipality). The municipalities play an important role in the planning and regulation of built environment as the European spatial planning system outlays certain building performance responsibilities to be fulfilled at the local level (DTU, 2009). The potentiality of municipalities to promote energy efficient buildings through municipal planning practices is large, since municipalities typically have a powerful local planning role in terms of developing local urban areas and authorizing local building projects. In the same context Eindhoven has expressed its vision 2040 to become an energy-neutral in all sectors, but the municipality aims to go energy neutral in the built environment, specially housing sector, by 2020 (Gemeente Eindhoven, 2009)

Practical realization of energy efficient housing developments requires a transition in existing systems and ways of doing in the building sector. This is currently not happening in the building sector due to a deadlock in supply and demand. The construction companies do not offer developers to build energy efficient buildings as they cannot identify sufficient demand from consumers and thus developers complain about the reluctance of construction companies to come up with viable solutions (Rohracher 1991). Lack of acceptance for energy efficient homes or buildings in the market is attributed to lack of strict regulations and appropriate forms of support for the stakeholders involved in housing sector & the end use customers. Lack of organized and structured process to be followed by the municipality in the planning, development and realization phases has further lead to poor collaboration & communication between various stakeholders.

BACKGROUND RESEARCH

Energy neutral homes have proven to benefit residents of lower energy costs, with even better quality and comfort of home (IEEE spectrum, 2010). Despite the advantages of energy saving measures for the house owners/ consumers, the steps taken so far by the Eindhoven municipality have not been successful in promoting them. Achieving energy neutral homes is technically very possible and research for the development of Blixe
Noord Oost has shown that this is also financially feasible (Petra rovers et al. 2009). However the role of the municipality and the redesign of development process are still needed to actually achieve the realization of energy neutral homes.

**Energy neutral housing developments**

An energy-neutral housing community is defined as a residential area where the net total energy used in all housing related processes and activities is generated within the district or community using renewable energy sources. The typical features of Energy neutral housing community are high energy efficient houses (high levels of insulation, air sealing etc), reduced carbon emissions and production of heat & electrical energy required by the home from decentralized renewable energy sources within or surrounding the community (NAHB, 2006). Energy neutral developments are different from other construction projects because of the energy issues related to them like the type of technology, design for efficiency, and generation of electricity within the community etc. In energy neutral/efficient housing developments the Local authorities (Municipalities) play an important role in promoting and facilitating the process. For employing energy neutral/efficient housing developments other parties or stakeholders like project developers, energy consultants and prospective owners/customers are also important (ENPIRE, 2009). The development process of energy neutral housing developments is broadly classified into planning, implementation and realization phases.

To promote energy efficient housing / buildings, the municipalities’ have to deal with different issues due to the complexity in the functioning of the local processes. As a result the municipalities of member states have combined a number of policy instruments and approaches in their planning practices in order to cope with the challenge of mobilizing change among local stakeholders. Some of the applied instruments are based within traditional planning frameworks based on ideas of regulation and support, whereas other instruments represent more innovative methods of facilitation (CONCERTO, 2009). Regulation is the strongest singular means to ensure that specific improved energy requirements in households are complied with in practice. Certain requirements are made directly binding for stakeholders involved in the building sector through a specific law passed by national government or municipality in its local plans. Support instruments are important since it involves some risks and losses to the stakeholders acting as prime movers. With financial support like economic subsidies and facilitation support like information on technology, demonstration programmes etc the idea is to compensate for the challenges involved in being prime mover and innovative to foster the transition process (DTU, 2009).

Thus the potentiality of municipalities to promote energy efficient buildings through municipal planning practices is large, since municipalities typically have a powerful local planning role in terms of developing local urban areas and authorizing local building projects. Besides having the authority to promote energy efficiency at the local level, municipalities also prove to have interests in doing so. To promote these interests there is a need for strict national level and local policies which are aimed at regulating and supporting this transition in housing sector.
Problem
The Dutch policy instruments have failed to instigate the adoption of energy efficiency and measures for energy neutral developments. The research by Beerepoot, 2007 shows that a broad scale adoption of energy efficiency measures fails to occur in the existing Dutch housing sector, which has related to the lack of structural cooperation between different actors in the mainly project-based building sector. The energy neutral housing ambition of Eindhoven is being affected due to lack of strict regulations & support instruments, lack of effective collaboration between stakeholders which has resulted in lack of market demand for energy neutral houses (Jan Bekering, 2009). The research conducted by Hans, Ingmar, 2008 on Groningen’s CO2 neutral ambitions shows that serious investments and/or collaborations of all stakeholders is necessary for such projects to become practically feasible. Thus the Eindhoven municipality now is aiming to actively cooperate with all actors and parties that can contribute to the Achieving the goal of energy neutrality between 2035 and 2045. The municipality is looking for the right examples, which are actively taking place as the latest developments and also from the developments proven in practice.

This has lead to failure of realizing energy neutral housing developments and thus curbed the progress towards energy neutral ambitions of Eindhoven. There is a need for municipality to promote energy neutral ambitions in housing sector through local means. This implies that greater attention is needed towards supporting and encouraging a new role for municipality in planning and regulating practices. So a key question arises, what kind of regulatory & support instruments are needed to regulate the interests of stakeholders towards energy neutral housing developments and what role should municipality play to promote collaboration among stakeholders and realize energy neutral housing developments.

RESEARCH METHODOLOGY

Desk research showed that Danish regulatory & support instruments are focussed on improving the energy efficiency of households and promoting renewable energy usage in housing sector through community owned cooperative farms. UK on the other hand has employed numerous financial support instruments like renewable heat incentive; LCBP grants, reduced VAT & Stamp duty etc. are available to promote carbon reduction using microgeneration technology and decentralized energy sources. Hence from the desk research the instruments regulating & supporting energy efficiency measures, carbon reduction measure, usage of renewable energy and financial incentives are found out. Further the Danish municipalities have promoted stakeholder participation in energy efficient housing developments by playing a proactive participatory role in the planning, implementation and realization phases of the projects. The experience of Danish municipalities show that the role played by municipalities has an effect on the type of instruments employed in the development process of the energy efficient housing projects. According to Hsin-Pin Fu et al, 2009 energy projects are evaluated in project performance by using the equal weights of performance criteria. Most studies, unfortunately, do not consider the importance degree of performance criteria. In fact the weights of performance criteria will be changed in different projects depending on local conditions. The instruments found from desk research on Denmark & UK are employed to achieve the local energy
ambitions successfully in their respective housing sectors. Thus in the energy neutral developments these regulatory and support instruments can be assumed as the performance criteria for determining their outcome. But the effectiveness/priority of performance criteria vary widely depending on the development and implementation of energy ambitions of different regions.

Analytical Hierarchy Process (AHP)
AHP provides a proven, effective means to deal with complex decision making and can assist with identifying and weighting selection criteria, analyzing the data collected for the criteria and expediting the decision-making process. It offers a way to integrate complexity, set the right objectives, establishes their priorities and determines the overall value of alternative solutions. It uses a multi-level hierarchical structure of objectives, criteria, sub criteria and alternatives. The pertinent data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion.

With the given decision problem of finding the prioritized instruments for energy neutral housing in Eindhoven, AHP can be used to find the weights of the instruments (performance criteria) found from the research and thus find the relative importance of once criteria over the other. This way the most prioritized/preferred Instruments for Eindhoven scenario can be found out. A survey questionnaire is designed to find the weights of the performance criteria using pairwise comparison approach. Pairwise comparisons are used to determine the relative importance of each alternative in terms of each criterion. Using 4 main criteria and 18 sub criteria 38 questions are framed for the questionnaire. In this approach the respondent has to express his opinion about the value of one single pairwise comparison at a time (choices shown in table1 below). The questionnaire is sent to 50 different experts representing stakeholder groups of Municipality, Project developers, Energy consultants & consumers and 25 responses are obtained. The discrete choices made by the respondents are converted into a numerical value determined for pairwise comparisons in the AHP according to the scale of set values: {9, 8, 7, 6, 5, 4, 3, 2, 1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9} (Saaty, 1980). The type of question used in the survey questionnaire and the assigned numerical values used to convert the discrete choices of respondents can be seen in table 1. To find the priority weights of instruments (criteria) based on all the 25 responses the mean value of all responses is calculated for each of the 38 questions. Further reciprocal and normal matrixes are used to compute priority vectors i.e. the priority weights of the instruments. The obtained priority weights are used to rank the instruments in order of descending weights and thus the relative importance of one instrument over another can is determined and prioritized instruments for Eindhoven are found out (figure 3). Similarly the priority weights of the instruments for the responses of each stakeholder group i.e. for customers (19), Energy consultants (2), Project developers (3) and Municipality (1) are found out. Thus the varying priority weights (preferences) of different stakeholder groups are also found out from the survey. The varying priority weights of regulatory and support instruments as preferred by individual stakeholder group are listed in table 2.
Table 1: Sample survey question and the assigned numerical value.

**Table 1:** Sample survey question and the assigned numerical value.

<table>
<thead>
<tr>
<th>A. Energy efficiency; B. Carbon reduction</th>
<th>Numerical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A &amp; B are equally important</td>
<td>(1)</td>
</tr>
<tr>
<td>A is slightly more important than B</td>
<td>(3)</td>
</tr>
<tr>
<td>A is absolutely more important than B</td>
<td>(5)</td>
</tr>
<tr>
<td>B is slightly more important than A</td>
<td>(1/3)</td>
</tr>
<tr>
<td>B is absolutely more important than A</td>
<td>(1/5)</td>
</tr>
</tbody>
</table>

**Figure 1:** Instruments found from desk research on Denmark & UK.

**Scenario Analysis**

To find the effect of the varying preferences of stakeholder groups and validate the role played by Danish municipalities for Eindhoven municipality a scenario analysis is conducted. This analysis is used to explain the effect of varying preferences of different stakeholder groups found from the survey and the role of Danish municipalities if adopted by Eindhoven municipality and implemented in reality. The scenarios are developed and reflected on Blixembosch Noord Oost energy neutral housing development using Global scenario analysis (John Ratcliffe, 2000).

An assumption, based on the research on Danish municipalities, is made for analyzing the scenarios that, “the role played by the municipality in the planning, implementation & realization phases, will result in the employment of specific type of instruments which will promote stakeholder participation and collaboration which indirectly determine the
outcome of the project”. Two scenarios are developed in this analysis. The first scenario assumes that in the present Blixembosch Noord Oost development the municipality adopts an existing housing development process. In the second scenario it is assumed that the municipality adopts the role of Danish municipalities for the development process. The outlay of the scenario is as follows.

Figure 2: The outlay of scenario analysis

<table>
<thead>
<tr>
<th>Main Instrument</th>
<th>Sub-Instrument</th>
<th>Municipality</th>
<th>Project Developer</th>
<th>Energy Cons</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficiency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Building code</td>
<td>0.541</td>
<td>0.414</td>
<td>0.247</td>
<td>0.282</td>
</tr>
<tr>
<td></td>
<td>Obligation for companies</td>
<td>0.460</td>
<td>0.254</td>
<td>0.323</td>
<td>0.240</td>
</tr>
<tr>
<td></td>
<td>Mandatory c. label/PC</td>
<td>0.155</td>
<td>0.242</td>
<td>0.263</td>
<td>0.258</td>
</tr>
<tr>
<td></td>
<td>Easements</td>
<td>0.250</td>
<td>0.216</td>
<td>0.181</td>
<td>0.174</td>
</tr>
<tr>
<td></td>
<td>Collaboration Manufacturers</td>
<td>0.044</td>
<td>0.129</td>
<td>0.139</td>
<td>0.170</td>
</tr>
<tr>
<td>Carbon reduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Building code</td>
<td>0.260</td>
<td>0.107</td>
<td>0.134</td>
<td>0.198</td>
</tr>
<tr>
<td></td>
<td>Obligation for households</td>
<td>0.460</td>
<td>0.252</td>
<td>0.528</td>
<td>0.245</td>
</tr>
<tr>
<td></td>
<td>Obligation Energy supplier</td>
<td>0.155</td>
<td>0.242</td>
<td>0.263</td>
<td>0.258</td>
</tr>
<tr>
<td></td>
<td>Planning permits</td>
<td>0.250</td>
<td>0.216</td>
<td>0.181</td>
<td>0.174</td>
</tr>
<tr>
<td></td>
<td>MCS &amp; Demonstration</td>
<td>0.044</td>
<td>0.129</td>
<td>0.139</td>
<td>0.170</td>
</tr>
<tr>
<td>Renewable Technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Community generation</td>
<td>0.140</td>
<td>0.196</td>
<td>0.134</td>
<td>0.243</td>
</tr>
<tr>
<td></td>
<td>Grid independent</td>
<td>0.058</td>
<td>0.357</td>
<td>0.573</td>
<td>0.330</td>
</tr>
<tr>
<td></td>
<td>Micro-gen technology</td>
<td>0.499</td>
<td>0.181</td>
<td>0.099</td>
<td>0.220</td>
</tr>
<tr>
<td></td>
<td>Electronic monitoring</td>
<td>0.161</td>
<td>0.162</td>
<td>0.233</td>
<td>0.285</td>
</tr>
<tr>
<td>Financial Support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feed in tariffs</td>
<td>0.282</td>
<td>0.300</td>
<td>0.190</td>
<td>0.164</td>
</tr>
<tr>
<td></td>
<td>Domestic green loans</td>
<td>0.059</td>
<td>0.283</td>
<td>0.486</td>
<td>0.277</td>
</tr>
<tr>
<td></td>
<td>Reduced VAT/stamp duty</td>
<td>0.081</td>
<td>0.181</td>
<td>0.262</td>
<td>0.257</td>
</tr>
<tr>
<td></td>
<td>Ren Heat incentive</td>
<td>0.500</td>
<td>0.322</td>
<td>0.087</td>
<td>0.201</td>
</tr>
</tbody>
</table>
Table 2: Preferred priority weights of individual stakeholder groups.
The outcome of the scenario is determined by adding the weights of the resulting instruments in the scenario as a result of role played by municipality. These weights are the averages of preferred instruments weights of stakeholders found from the survey (table 2). The Present scenario role showed an outcome of 0.457 and the participatory role of the municipality gave an outcome of 0.731. This clearly suggested that to promote energy neutral housing developments the Eindhoven municipality needs to play a participatory role in terms of actively participating in all the phases of project development.

CONCLUSIONS

Eindhoven needs to focus primarily on improving energy efficiency in households. There is a need for employing stricter building regulations. This needs to be complemented with strong financial support in terms of Renewable heat incentives, feed in tariffs and tax/stamp duty rebates. Further community generation should be prioritized for new housing communities. Stakeholders want strict building codes to regulate use of microgeneration at household level to reduce carbon emissions.

Promoting stakeholder interests rather than self interests should be the main priority for Municipalities in energy neutral developments since such projects are still in its early implementation stages and thus pose great technical and implementation difficulties for stakeholders. Municipality should regulate energy neutral requirements effectively through its land allocation plans. The active participation of municipality in all the phases of the project is necessary to ensure success in energy neutral development projects. Energy neutral ambitions should be propagated to local citizens during the planning stages and prospective customers should be involved in all the project phases. Good collaboration with technology and material manufacturers is necessary to provide technical support and reduce financial burden for project developers.

Figure 3: Role required to be played by Eindhoven municipality
Figure 2.13: Prioritized instruments for Eindhoven scenario

RECOMMENDATIONS & DISCUSSION

Research shows that community owned generation is highly preferred for Eindhoven. This is a compulsory requirement for energy neutral housing developments since it reduces the financial burden on the consumers by allowing cooperative investments. Eindhoven municipality should learn from the Danish wind cooperatives established on share basis investments. Currently financial incentives are available to install microgeneration technology & energy efficiency measure in existing houses. Municipality should consider extending the financial incentives for new houses also. This study only considers the preferences of stakeholder groups to evaluate the instruments required for Eindhoven scenario. More studies to evaluate these instruments in terms of legal, financial and technical feasibilities are needed to be carried out. The instruments and the role of municipality are discussed in relation to only private energy housing developments. The same research can be carried out in case of social housing or housing renovation projects.

This research aims at finding a practical approach for realizing Energy neutral housing developments. Therefore the relevant background literature and information on desk research was collected from reports, internet articles and case studies. This approach suits the research since the aim is to learn from the experiences of the European Union.

REFERENCES


CURRICULUM VITAE

Author: Sahul Reddy Kadarpeta
‘Promoting the need for a special role of municipalities for successful realization of energy ambitions in housing sector.’

Sahul reddy kadarpeta is a currently a master student of Construction management & Engineering at Technical university of Eindhoven, the Netherlands.

s.s.r.kadarpeta@student.tue.nl

2004-2008 Bachelors Civil Engineering, VIT University, India
05/07-06/07 Trainee at Indu projects ltd, India
06/09-08/09 Traineeship at Tempus infra Projects Pvt. Ltd, India
2008-2010 Masters Construction management & Engineering, TU/e, the Netherlands.
Kenniscluster Energieneutraal Wonen in Brainport (KENWIB)

Partners
Gemeente Eindhoven
Provincie Noord-Brabant
Stichting Promotie Installatietechniek
Technische Universiteit Eindhoven