D3.3 Identifying barriers, solutions and best practices for energy renovations

The results of a literature survey, questionnaire, interviews and a workshop
## Contents

Executive summary................................................................................................................. 4

1  Introduction.......................................................................................................................... 10

2  Barriers and solutions – literature study............................................................................ 12
   2.1  Introduction...................................................................................................................... 12
   2.2  Energy consumption in European dwellings................................................................. 12
      2.2.1  European housing stock......................................................................................... 12
      2.2.2  Energy consumption ............................................................................................. 13
   2.3  Barriers................................................................................................................................ 16
      2.3.1  Technical barriers................................................................................................... 17
      2.3.2  Financial barriers................................................................................................... 18
      2.3.3  Organisational barriers ......................................................................................... 19
   2.4  Possible solutions to overcome barriers........................................................................ 20
      2.4.1  Technical solutions ............................................................................................... 21
      2.4.2  Financial solutions ............................................................................................... 21
      2.4.3  Organisational solutions ...................................................................................... 22

3  Barriers and solutions – questionnaire ............................................................................. 23
   3.1  General characteristics and policies ............................................................................. 23
      3.1.1  Characteristics of the housing stock........................................................................ 23
      3.1.2  Organisational policies .......................................................................................... 24
      3.1.3  Belgium.................................................................................................................... 25
      3.1.4  France..................................................................................................................... 27
      3.1.5  Netherlands............................................................................................................. 28
      3.1.6  Spain....................................................................................................................... 31
      3.1.7  United Kingdom..................................................................................................... 32
   3.2  Barriers............................................................................................................................ 34
      3.2.1  Technical barriers.................................................................................................... 34
      3.2.2  Financial barriers.................................................................................................... 36
      3.2.3  Organisational barriers ......................................................................................... 38
   3.3  Solutions.......................................................................................................................... 40
      3.3.1  Technical solutions ............................................................................................... 40
      3.3.2  Financial solutions ............................................................................................... 41
      3.3.3  Organisational solutions ...................................................................................... 43
      3.3.4  Overall findings..................................................................................................... 44
   3.4  Most and least effective energy saving measures......................................................... 44
   3.5  Conclusions..................................................................................................................... 47
Executive summary

Tenants in social housing can save energy by changing their behaviour and by buying energy efficient appliances. Social housing organisations (SHOs) can help them by purchasing energy efficient installations for their dwellings and by carrying out energy renovations. However, SHOs often encounter technical, financial and/or organisational barriers in carrying out these energy renovations.

This report will help SHOs to identify these barriers and to find solutions to overcome these barriers. The report is a result of the work carried out in the TRIME project. The sources for this study are:

- A literature study to find barriers and solutions to overcome them;
- A questionnaire carried out amongst 27 SHOs in the Netherlands, Belgium, France, Spain and United Kingdom, to find what barriers these SHOs encounter when carrying out energy renovations, and how they overcome these barriers;
- Interviews with four TRIME SHOs for further in-depths analysis of the barriers and solutions
- Workshop with Dutch and Belgian SHOs with further discussion of the barriers and solutions

The following technical barriers were identified, sorted from most often to least often recognised by the respondents of the questionnaire:
<table>
<thead>
<tr>
<th>1. <strong>Technical barriers</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Technical limitations of existing building stock</td>
</tr>
<tr>
<td>2. Planning authorities often pose restrictions on the renovation of heritage buildings. Only a limited amount of renovation measures are suited for these types of buildings</td>
</tr>
<tr>
<td>3. The contractor is not always familiar with the most recent energy efficient solutions due to the high pace of solutions being developed</td>
</tr>
<tr>
<td>4. Professionals (architect, MEP-consultant or other independent advisors) are not always up to date with the most energy efficient solutions due to the high pace of new developments</td>
</tr>
<tr>
<td>5. Too often the focus is on individual products instead of integrated renovation plans</td>
</tr>
<tr>
<td>6. Long period of testing and development before innovative solutions gain approval for widespread application in buildings</td>
</tr>
<tr>
<td>7. Lack of information on the long-term failure risks that could occur in energy efficient renovated dwellings</td>
</tr>
<tr>
<td>8. Lack of knowledge and experience in social housing organisations about new energy efficient technologies</td>
</tr>
<tr>
<td>9. SHOs often want to keep the same brand/device in their building stock to keep the maintenance work consistent</td>
</tr>
<tr>
<td>Financial barriers</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>1. Lack of funds</td>
</tr>
<tr>
<td>2. The most ambitious renovations will require more funding upfront compared to common renovations. With a tight budget it’s likely that corporations will compromise on spending on energy efficient measures</td>
</tr>
<tr>
<td>3. The social housing organisation makes the investment but does not gain the benefits from the investment. This problem is known as: ‘split incentive barrier’, ‘landlord/tenant barrier’, ‘investor/user barrier’, or ‘principal/agent barrier’</td>
</tr>
<tr>
<td>4. Competing purchase decisions, investments in energy efficiency are not always considered the most important/popular investment for a social housing organisation</td>
</tr>
<tr>
<td>5. The energy efficiency measures are not reflected in the market price of the building, and the measures taken are often not visible</td>
</tr>
<tr>
<td>6. Tenants are not willing to invest in the dwelling themselves because they believe that the main beneficiary of the investments is the owner of the building or they consider this a task of the social housing organisation</td>
</tr>
<tr>
<td>7. Due to changing policies, it is more difficult to obtain loans for social housing organisations</td>
</tr>
<tr>
<td>8. Future energy prices are unclear, and actual return costs are therefore difficult to calculate</td>
</tr>
</tbody>
</table>
### Organisational barriers

1. **Existing buildings are often in use**

2. **It is difficult to reach the 70% consensus (which has to be reached in a majority of the European countries) among the occupants because:**
   - Occupant often refuse to cooperate with renovations because it changes the appearance of the dwelling
   - Occupants often refuse to cooperate with renovations due to fear of rent increase;
   - Occupants often refuse to cooperate with renovations due to expected disturbance and inconvenience;
   - Occupants are not willing to cooperate due to lack of trust in social housing organisations;

3. **Lack of a general understanding about energy efficiency goals**

4. **Building regulations are mainly focussing on new buildings and not on existing buildings**

5. **If building codes are too prescriptive, they could hinder innovations**

6. **Advisors and designers are often involved too late in the process**

7. **Lack of time for the design process**

---

The following solutions to overcome these barriers were found (sorted from most often to least often used by the respondents of the questionnaire):

### Technical solutions

1. **Combine regular maintenance with implementation of energy saving measure**

2. **Gather the experience from previous projects and document those structurally. These can be used as a reference guide**

3. **Offer educational programs for professionals to keep them up to date**
4. Organise energy performance based tenders

5. Make use of BIM (Building information model)

### Financial solutions

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Conventional financing: tenants will be completely/partly charged for the investment by means of rent increase</td>
</tr>
<tr>
<td>2.</td>
<td>Living Expenses Guarantee: Housing association gives tenants a guarantee that the total living expenses (consisting of the rent and secondary expenses like energy costs, cable and telephone) during a certain period of time will not increase more than the inflation rate. This removes the rent increase barriers for tenants</td>
</tr>
<tr>
<td>3.</td>
<td>The energy rating will result in an increased market value of the dwelling after renovation</td>
</tr>
<tr>
<td>4.</td>
<td>Energy Performance Contract: Investments and accompanying services regarding the realisation and monitoring of energy saving measures are financed from the generated savings on energy consumption. The contract is made between tenants, the housing association and an external party for a longer period (approximately 10 years). The energy performance contract is mostly focused on (collective) energy supply with accompanying energy management/administration</td>
</tr>
<tr>
<td>5.</td>
<td>Energy accounts through the housing cooperative: A housing association invests in refurbishment and at the same time agrees on a collective agreement with the energy supplier (negotiating lower rates than a single tenant could get). Tenants will pay the energy bill to be cooperative. As a result, they will get their rent and energy costs on one bill, showing rent increase and energy cost decrease</td>
</tr>
</tbody>
</table>

### Organisational solutions

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tenants are likely to be more open towards renovation when the increased comfort as a result of renovation is clear to them</td>
</tr>
<tr>
<td>2.</td>
<td>Consultants and designers should be involved early in the process</td>
</tr>
<tr>
<td>3.</td>
<td>Renovation could be combined with upgrading the neighbourhood (regeneration)</td>
</tr>
</tbody>
</table>
4. **Introduction of the building energy rating** should result in more awareness among tenants.

5. **Education programs** could make the social housing organisations more aware of the importance of energy efficiency.

6. **Projects that are well documented** should be publicised among experts and social housing organisations in order to stimulate how future projects are executed.

7. **Publicity campaign**

Furthermore, best practices for energy renovations for the following building parts and financing solutions were described:

- Glazing (section 5.2)
- Insulation (section 5.3)
- Heating systems (section 5.4)
- Ventilation systems (section 5.5)
- Solar panels (section 5.6)
- Energy performance contracts (section 5.7)
1 Introduction

Tenants of social housing can save energy by changing their behaviour and by buying energy efficient appliances. Social housing organisations (SHOs) can help tenants by purchasing energy efficient heating, cooling, hot water and ventilation installations for their dwellings and by carrying out energy renovations. However, SHOs often encounter technical, financial and/or organisational barriers in carrying out these energy renovations, such as a lack of time, shortage of budget or limited technological knowledge, and as a result, poor or sub-optimal choices are often made. However, successful previous projects such as ‘Koningsvrouwen van Landlust’ by Eigen Haard, have shown that barriers can be overcome.

In this report, we investigated which barriers prevent social housing organisations from investing in energy efficient measures and which measures they could take to overcome these barriers. The barriers are identified through a literature study, followed up via a questionnaire with 27 social housing organisations in the 5 TRIME countries (Belgium, France, the Netherlands, Spain, and United Kingdom) and an interview among four TRIME members. Alongside looking at the barriers to energy renovation we also looked at possible solutions; again using a literature study, questionnaire and interviews. Additionally a workshop with social housing organisations from Belgium and the Netherlands was held to discuss the barriers and find new solutions.

Chapter 2 of this report explains the barriers and solutions for energy renovations as found in the literature study. The findings of the questionnaire are described in Chapter 3. The results of the in-depths interviews on the barriers and possible solutions are described in chapter 4. Chapter 5 describes several best practice examples based on the literature study, the questionnaire, and the interviews. In Chapter 6, we show a summary of the barriers and solutions we found during the workshop. A more detailed description of the workshop can be found in the report ‘D3.4 Report Co-creation Workshop. Chapter 7 gives a summary of the most important barriers and solutions to overcome these barriers to encourage greater energy efficient purchasing behaviour by social housing organisations.
Figure 1  Age profile of residential floor space: source BPIE survey (Atanasiu et al., 2011)
2 Barriers and solutions – literature study

This chapter shows the results of a literature review that researched the potential for social housing organisations to invest in energy efficient measures, and possible solutions to overcome barriers. The findings of this literature study are used as input for the questionnaire (Chapter 3).

2.1 Introduction

Reducing energy consumption in 2020 by at least 20% compared with levels of 1990 is the goal that EU-members set for themselves. 40% of the total energy consumption in Europe is for domestic use. Therefore, energy saving in residential building stock is one of the main focus points of European countries.

During the TRIME project, tenants will be enticed to change their energy use behaviour. Besides this, the social housing organisations can contribute to saving energy by purchasing more energy efficient installations and improving the building characteristics. If all existing buildings in Europe would be renovated, 60% of the total energy consumption for heating could be saved (Tommerup and Svendsen, 2006). Despite this enormous potential, renovating is only carried out in a low number of dwellings, even though most energy saving measures are cost effective during the lifetime of the measure.

Section 2.2 discusses the current energy consumption in the European housing stock and the ways of how energy is consumed in dwellings. Section 2.3 describes the potential barriers that social housing organisations encounter when upgrading their housing stock. Section 2.4 identifies solutions to overcoming these barriers to enable social housing organisations to increase the energy efficiency of their dwellings.

2.2 Energy consumption in European dwellings

2.2.1 European housing stock

Overall the housing stock of the EU has 206.7 million dwellings. 64% of these dwellings are single-family houses and 36% are multi-family dwellings. All European countries have a majority of single family houses, except Spain, Estonia and Latvia (Atanasiu et al., 2011). Each year, 2.3 million new dwellings are built (1.1%), and about 0.3% of the existing dwellings are demolished (Milin et al., 2011a). This means that the building stock is increasing slowly.

Figure 1 shows a division of the European building stock in three building time periods: “Old buildings” (built until 1960), “Modern buildings” (built from 1961 to 1990) and “Recent buildings” (built from 1991 to 2010). Older buildings are generally less energy efficient than recent buildings, as building regulations have become stricter in terms of energy efficiency. Figure 1 also shows a large construction boom in Europe between 1961-1990; the total building stock was doubled in most European countries. Those buildings are often poorly insulated. Recent buildings are well insulated and are more energy efficient, but only a small share of the total current housing stock are recently built.
The majority of European dwellings are “owner-occupied” (Figure 2), except for Switzerland which has a larger share of rental dwellings (Atanasiu et al., 2011). The rental dwellings can be divided into social and private rent. The British, Dutch, French and Austrian housing stock have a significant share of socially rented housing stock compared to the other countries (Atanasiu et al., 2011). Social housing organisations are generally seen as the most effective method to improve energy efficiency in dwelling stock, because they have a significant number of dwellings per organisation, whereas owner-occupied dwellings have to be approached per person. Furthermore, social housing organisations have a social responsibility to provide adequate and affordable housing, in contrast to the private sector that is often primarily focused on profit.

2.2.2 Energy consumption

Energy generation and consumption are different in different countries, depending on the available energy sources, tradition, and climate. European energy still relies mainly on fossil fuels. However, the use of sustainable energy sources is increasing; Austria, Finland and France make significant use of combustible renewable and waste sources (more than 20%) and the amount of dwellings with district heating is increasing, especially in Finland, Sweden and Germany (Atanasiu et al., 2011). Electricity has the potential to be produced sustainably, but the amount of sustainable electricity production is still limited. Currently the electricity production is different per EU country. Austria, Sweden and Switzerland largely make use of hydropower (more than 50%). Nuclear power is used in large amounts in France (75%), Sweden (50%), and Switzerland (45%) (Atanasiu et al., 2011). The UK and the Netherlands use mainly gas, and coal is still widely used in most EU countries (Atanasiu et al., 2011). Electricity generated by renewable energy sources is rather limited, but electricity production with biomass and wind farms is growing.

Figure 2 Tenure of residential buildings in Europe Source: BPIE survey (Atanasiu et al., 2011)
The combination of building characteristics and occupant behaviour determines how much energy is used in dwellings. With their purchase behaviour, social housing organisations have significant influence on the energy consumption of their tenants. They determine the types of insulation, heating system, ventilation system, hot tap water system and communal lighting in communal spaces in their dwellings. Since the oil crisis of the 1970s, the building industry is developing measures to increase the energy efficiency of dwellings. The social housing organisations have to decide which measure to apply in their building stock.

Residential energy consumption can be divided in different categories:

- Energy for heating/cooling
- Energy for hot tap water
- Energy for lighting
- Energy for electrical appliances.

### 2.2.2.1 Heating systems

Space heating is responsible for a substantial share of the total energy consumption in a building. The magnitude of the share for heating is dependent on the countries’ climate, the physical characteristics of the dwelling and the characteristics of the heating device in the dwelling; e.g. the share of heating in Poland is significantly higher than the share of heating in Spain (Atanasiu et al., 2011). On average 55-70% of the total energy consumption in a dwelling in Europe is used for space heating. (Meijer et al., 2009). Although energy consumption for heating is lower in the southern countries of Europe, their total energy consumption is relatively high; this can be caused by insufficient insulation or the fact that cooling by air-conditioning is an important contributor to the overall consumption in those countries.

Heat for space heating can be generated by using different sources. The majority of heating in European residential stock is generated by gas, but coal, oil, electricity, district heating and renewable resources are used to generate heat. Coal is still commonly used in the central and eastern part of Europe, while oil is more common in the north and western part of Europe (mainly in Germany and France). The central & eastern parts of Europe have a significant share of district heating, while this is rarely used in the southern part of Europe. The use of renewable sources is increasing and is currently mostly used in the central and eastern part of Europe, followed by the southern part.

Space heating can be carried out by several types of devices: (Itard et al., 2008, Meijer et al., 2009, Atanasiu et al., 2011):

- local heating with wood/biomass
- local electrical heating
- local heating with gas/oil
- central heating with wood/biomass
- central heating with gas or oil
- high efficiency central heating with gas or oil
- district heating with fossil fuel
- district heating with biomass
• district heating with waste heat
• active solar heating
• heat pump

About 70% of European buildings use central heating based on fossil fuels or biogas. Although energy inefficient, local heating devices (stoves) still represent 5-17% of the heating systems in Austria, Germany, the Netherlands and Switzerland (Meijer et al., 2009). In dwellings with local heating, often not all rooms are being heated, thus counterbalancing the inefficiency compared with central heating. Electrical heating is also seen as a non-sustainable way of producing heat, unless the electricity is produced by renewable sources (e.g. PV panels), which is currently not the case in most countries. In France and Finland, a substantial share of the dwellings use electrical heating.

The largest share of dwellings using district heating are in Sweden and Finland (Meijer et al., 2009). In other countries, the share of district heating is small, but increasing. Another upcoming highly energy efficient heating device in Europe is the heat pump: 5% of single-family dwellings in Switzerland already have a heat pump (Meijer et al., 2009).

Heat distribution for central heating systems can be carried out using high temperature systems (70-90°C) or low temperature systems (45-55°C). A low temperature system requires less energy, but it requires a larger radiator surface to release the heat. The most common distribution system of heating in Europe is via radiators (Itard et al., 2008). The majority of the radiators make use of high temperature heating. The share of low temperature floor heating is rapidly increasing. Apart from surface heating, there are also dwellings that use air heating. Air heating is mainly used in the southern countries of Europe because an air heating system is often also suitable for cooling.

2.2.2.2 Hot tap water

Hot tap water in domestic buildings can be generated with different devices. Electric water heating systems generate 30% of the domestic hot water (Meijer et al., 2009). Dwellings with central heating systems often have combination boilers that produce both heat and hot tap water. Local heating systems are, despite their energy inefficiency, still commonly used in the domestic housing sector. Even local gas heaters, like geysers (open combusting appliances) are regularly applied, despite the risk of carbon monoxide poisoning. The number of geysers is decreasing and some social housing organisations (for example in the Netherlands) even have an active policy to replace these systems. Dwellings that are heated with district heating frequently use district heating for hot tap water (with the proviso that the temperature is high enough) (Itard et al., 2008). Solar boilers are least used, although especially in the countries with a warmer climate solar boilers are emerging (Itard et al., 2008).

Types of hot water generators (Itard et al., 2008):

• wood stove
• individual gas/oil heater
2.2.2.3 Ventilation
Ventilation in dwellings is necessary to remove moisture and harmful substances from the indoor environment. Especially in recently built airtight buildings, mechanical ventilation is necessary, because there is little natural ventilation through gaps and cracks of the building. Heat/cold losses through the ventilation system can be minimized by mechanical ventilation with heat recovery (using the exhaust ventilation to warm up the incoming air). Most of the European dwellings have natural ventilation. Finland, France and the Netherlands have a significant share of dwellings that have mechanical exhaust ventilation. Mechanical ventilation with heat recovery is used in 20% of the Finnish dwellings and 10% of the Dutch dwellings; in other European countries, heat recovery ventilation is not commonly applied. (Itard et al., 2008).
Buildings can also be ventilated based on the principle of overpressure (mechanical inlet, natural exhaust). This system is rarely applied in dwellings, as it consumes more energy and the installation has to be done very precisely. Mechanical ventilation systems can be coupled with CO₂-based control systems to optimise the ventilation rate according to the presence of the residents.

Types of ventilation (Itard et al., 2008):
- Natural cross ventilation through windows or ventilation grilles
- Mechanical inlet/natural exhaust ventilation
- Natural inlet/mechanical exhaust ventilation
- mechanical inlet and exhaust ventilation (possibly with heat recovery)

2.2.2.4 Lighting
Social housing organisations are only responsible for the lighting in communal areas. The percentage of LED lighting installation in communal areas is increasing (Atanasiu et al., 2011).

2.3 Barriers
Social housing organisations experience several barriers when improving the energy efficiency of their building stock. As a result, they are often not yet implementing the most energy efficient solutions. This section summarises the studies of Cadima (2009), Atansiu et al. (2011), Häkkinen and Belloni (2011), Meijer et al. (2009), (Itard et al., 2008) on barriers for social housing organisations to purchase energy efficient installations for their dwellings.

The possible barriers can be divided in three main categories:
- Technical barriers
- Financial barriers
- Organisational barriers
2.3.1 Technical barriers

1. Technical limitations of existing building stock (Atanasiu et al., 2011);

2. Planning authorities often pose restrictions towards the retrofit of heritage buildings. Only a limited amount of retrofit measures are suited for these types of buildings (Atanasiu et al., 2011).

3. The contractor is not always familiar with the most recent energy efficient solutions due to the high pace of solutions development (Atanasiu et al., 2011).

4. Professionals (architect, MEP-consultant or other independent advisors) are not always up to date with the most energy efficient solutions due to the high pace of new solutions on the market (Atanasiu et al., 2011).

5. Too often the focus is on individual products instead of integrated renovation plans; (Atanasiu et al., 2011)

6. Long periods of testing and development before innovative solutions gain approval for widespread application in buildings (Donkelaar et al., 2006).

7. Lack of information on the long-term failure risks that could occur in energy efficient retrofitted dwellings.

8. Lack of knowledge and experience in social housing organisations about new energy efficient technologies (Atanasiu et al., 2011).

9. Companies often want to keep the same brand/device in their building stock to keep the maintenance work consistent (Meijer et al., 2009, Itard et al., 2008);

Technical limitations of the existing building stock are often mentioned as one of the barriers to invest in energy efficiency. The quality, age, dimensions and layout of the building can lead to several obstacles e.g. post insulation can result in an increased amount of moisture problems.

Furthermore, there is a lack of knowledge and experience of new energy efficient technologies within the organisations, and organisations do not want to take the risk of technical problems and unforeseen costs.

Maintenance is an important aspect of the work of a social housing organisation; and there are implications between the energy efficiency of the ventilation and heating systems. E.g. the energy efficiency of a ventilation system decreases when the filter is filthy. In order to keep the maintenance consistent, it is often decided to keep the same installations instead of installing more energy efficient installations.
2.3.2 Financial barriers

1. Lack of funds (Atanasiu et al., 2011)

2. The most ambitious retrofits will require more funding upfront compared to common retrofits. With a tight budget it's likely that corporations will compromise on spending on energy efficient measures. (Atanasiu et al., 2011)

3. The social housing organisation makes the investment but does not gain the benefits from the investment. This problem is known as: ‘split incentive barrier’, ‘landlord/tenant barrier’, ‘investor/user barrier’, or ‘principal/agent barrier’. (Atanasiu et al., 2011, Cadima, 2009)

4. Competing purchase decisions, investments in energy efficiency are not always considered the most important/popular investment for a social housing organisation; (Atanasiu et al., 2011)

5. The energy efficiency measures are not reflected in the market price of the building, while the measures taken are often not visible (Meijer et al., 2009, Atanasiu et al., 2011).

6. Tenants are not willing to invest in the dwelling themselves because they believe that the main beneficiary of the investments is the owner of the building or they consider this a task of the Social housing organisation; (Atanasiu et al., 2011)

7. Due to changing policies, it is more difficult to obtain loans for social housing organisations (Atanasiu et al., 2011)

8. Future energy prices are unclear, and actual return costs are therefore difficult to calculate. (Atanasiu et al., 2011)

9. Higher insurance cost because of the uncertainty of new techniques (Donkelaar et al., 2006)

The majority of the social housing organisations are not allowed to increase the rent for current tenants, not even if the energy saving is a substantial part of the energy costs. The Netherlands and the Czech Republic are two of the few countries that allow rent increase after renovating. In the Netherlands the increased rent can be compensated by government subsidies for tenants.

Legal limits in rent are another obstacle. Without rent increase, housing organisations cannot earn back their investments. One possibility would be to request tenants to invest in energy efficiency measures themselves, but they often do not have the money for it, and they rarely see the benefits of investing in renovation. They believe that the main beneficiary of the investments is the owner of the building.
2.3.3 Organisational barriers

1. Existing buildings are often in use; (Donkelaar et al., 2006, Atanasiu et al., 2011, Häkkinen and Belloni, 2011)

2. It is difficult to reach the 70% consensus (which has to be reached in a majority of the European countries) among the occupants because (Donkelaar et al., 2006):
   - Occupant often refuse to cooperate with renovations because it changes the appearance of the dwelling
   - Occupants often refuse to cooperate with renovations due to fear of rent increase;
   - Occupants often refuse to cooperate with renovations due to expected troubles and inconvenience;
   - Occupants are not willing to cooperate due to lack of trust in social housing organisations;

3. Lack of a common understanding about energy efficiency goals; (Atanasiu et al., 2011)

4. Building regulations are mainly focusing on new buildings and not on existing buildings; (Atanasiu et al., 2011)

5. If building codes are too prescriptive, they could hinder innovations; (Atanasiu et al., 2011)

6. Advisors and designers are often involved too late in the process; (Donkelaar et al., 2006, Häkkinen and Belloni, 2011)

7. Lack of time for the design process; (Atanasiu et al., 2011)

The existing building stock is often occupied, and for renovation occupants often need to move temporarily. Furthermore, occupants often refuse to consent with the renovation due to fear of rent increase and hassle that comes with a renovation.

Although building regulations could stimulate energy efficiency in buildings, they could also slow down the process. If building regulations are too prescriptive, they could hinder innovations. Furthermore, the building regulations are mainly focused on new buildings and not on existing buildings. The planning and design process is an important phase to implement energy saving measures. To set up an energy efficient renovation plan, all team members should adopt the energy
efficiency objectives at an early stage of the process. Currently, advisors and designers are often involved too late in the process, and therefore energy saving measures are not fully optimised. During the design process, it is important to have a common understanding about sustainability. The lack of a common understanding could result in team members with different and possibly contradicting goals. Contradictory goals will hinder the cooperation and hinders the creation of innovative solutions.

Design of energy efficient buildings needs integrated methods. Building Information Models (BIM) are claimed to be an important solution for efficient integrated design. To get the design accepted and better adapted to the needs of users, it is important to involve users in the design process. Lack of time for the design process is another obstacle that hinders social housing organisations to invest in (the design of) energy efficient buildings.

2.4 Possible solutions to overcome barriers
This paragraph will briefly describe some solutions to overcome the barriers described in literature (Cadima, 2009, Häkkinen and Belloni, 2011, Tommerup and Svendsen, 2006).

Technical limitations of energy saving measures in existing building stock can be overcome with careful planning and design. Involving the occupant in the process and keeping them informed can instigate cooperation of the occupants. Occupants should be advised that the physical improvement of the building shall not only lead to reduced energy consumption, but often to improved comfort. The problem of mixed ownership could be overcome by hiring a building manager who could help with the communication among tenants. It is important to design and plan with all stakeholders (housing owners, advisors, planners etc.) from the start of the project to achieve the best’ plan for each specific case. To get cooperation from the tenants, energy saving measures with the least impact on the layout of the dwelling may be chosen. For example, district heating has a limited impact on a building layout, because the space needed for district heating is insignificant.

To avoid identified barriers, a good procedure for a renovation team (social housing organisation, building company and advisors) to implement energy saving measures in a dwelling is:

- Identifying which renovation strategy is best suited for the specific situation
- Offering enough support and advice to the building owner during the decision process
- Creating planning advice for a detailed concept of renovating measures

Implementing good quality assurance in the renovation project Monitoring and control of key information


2.4.1 Technical solutions

1. Combine regular maintenance with implementation of energy saving measures. (Donkelaar et al., 2006)

2. Gather the experience from previous projects and document these. They can be used as a reference guide (Donkelaar et al., 2006)

3. Offer educational programs for professionals to keep them up to date (Atanasiu et al., 2011)

4. Organise energy performance based tenders (Donkelaar et al., 2006)

5. Make use of BIM (Building information model) (Häkkinen and Belloni, 2011)

2.4.2 Financial solutions

1. Conventional financing: tenants will be completely/partly charged for the investment by means of rent increase (Donkelaar et al., 2006)

2. Living Expenses Guarantee: Housing association gives tenants a guarantee that the total living expenses (consisting of the rent and secondary expenses like energy costs, cable and telephone) during a certain period of time will not increase more than a common inflation rate. This removes the rent increase barriers for tenants. (Donkelaar et al., 2006)

3. The energy rating will result in an increased market value of the dwelling after renovation. (Häkkinen and Belloni, 2011)

4. Energy Performance Contract: Investments and accompanying services regarding the realisation and monitoring of energy saving measures are financed from the generated savings on energy consumption. The contract is between tenants, the housing association and an external party for a longer period (approximately 10 years). The energy performance contract is mostly focused on (collective) energy supply with accompanying energy management/administration. (Donkelaar et al., 2006, Itard et al., 2008)

5. Energy accounts through the housing cooperative: A housing association invests in refurbishment and at the same time agrees on a collective agreement with the energy supplier (negotiating lower rates than a single tenant could get). Tenants will pay the energy bill to be cooperative. As a result, the resident will get the rent
and energy costs on one bill, showing rent increase and energy cost decrease

2.4.3 Organisational solutions
1. Existing buildings are often in use; (Donkelaar et al., 2006, Atanasiu et al., 2011, Häkkinen and Belloni, 2011)

2. It is difficult to reach the 70% consensus (which has to be reached in a majority of the European countries) among the occupants because (Donkelaar et al., 2006):
   - Occupant often refuse to cooperate with renovations because it changes the appearance of the dwelling
   - Occupants often refuse to cooperate with renovations due to fear of rent increase;
   - Occupants often refuse to cooperate with renovations due to expected troubles and inconvenience;
   - Occupants are not willing to cooperate due to lack of trust in social housing organisations;

3. Lack of general understanding of energy efficiency goals; (Atanasiu et al., 2011)

4. Building regulations are mainly focussing on new buildings and not on existing buildings; (Atanasiu et al., 2011)

5. If building codes are too prescriptive, they could hinder innovations; (Atanasiu et al., 2011)

6. Advisors and designers are often involved too late in the process; (Donkelaar et al., 2006, Häkkinen and Belloni, 2011)

7. Lack of time for the design process; (Atanasiu et al., 2011)
This chapter outlines the barriers that social housing organisations experience when investing in energy efficient building devices and to indicate possible solutions to overcome these barriers.

The data for this chapter is collected via a questionnaire. The questionnaire was distributed among social housing organisations (SHOs) in the five TRIME countries (Belgium, France the Netherlands, Spain and UK). The original aim was to gain 35 respondents; we gathered 27 responses among the five different TRIME countries. The amount of respondents is insufficient to gain a representative overview, but it does give a clear indication of the current situation. To prevent language barriers, the questionnaire was translated from English to French, Dutch and Spanish. The questionnaire contained both open and multiple choice questions and the questions are based on the findings in the literature review (chapter 2).

Table 1 Respondents questionnaire

<table>
<thead>
<tr>
<th>Country</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flanders</td>
<td>6</td>
</tr>
<tr>
<td>France</td>
<td>6</td>
</tr>
<tr>
<td>Netherlands</td>
<td>6</td>
</tr>
<tr>
<td>Spain</td>
<td>4</td>
</tr>
<tr>
<td>UK</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
</tr>
</tbody>
</table>

The first section of this chapter describes the general characteristics of the dwelling stock of the respondents and the general policies of the SHOs regarding renovation. The second section presents the barriers for energy renovating that the respondents experienced. The third section presents several possible solutions to overcome these barriers. The fourth section lists the most and least effective energy saving measures, according to the respondents. The final section gives the conclusions of the survey.

3.1 General characteristics and policies
This section describes the general characteristics of the housing stock of the respondents of the questionnaire in comparison with the literature study in Chapter 2, and the renovation policies of the SHOs. A more detailed description of the current situation per TRIME country is given.

3.1.1 Characteristics of the housing stock
The results from the questionnaire show a large diversity of building installations within the housing stocks of the responding social housing
Organisations (SHOs). A majority of the social housing organisations that completed the questionnaire has dwellings with a central heating system with gas/oil as energy source. Local electrical heating is another device that is present in a majority of the responding SHOs. Few SHOs have dwellings with active solar heating systems, heat pumps or air conditioning systems. In the Netherlands, we found a relatively large amount of SHOs that have dwellings with district heating with waste heat, and in France there is a relatively large amount of SHOs that have dwellings with district heating based on biomass. None of the respondents mention local heating with wood/biomass as primary heating system in their dwellings.

The combination boiler is a hot water system that is present in the majority of the housing stock of the surveyed SHOs. Solar hot water panels have the lowest penetration factor in the surveyed housing organisations, but in Spain all SHOs indicate that they have dwellings with solar hot water panels.

A majority of the responding SHOs have dwellings with natural ventilation and mechanical exhaust ventilation, but the number of SHOs with mechanical exhaust ventilation with CO₂ detection and ventilation systems with heat recovery is significantly lower.

No questions were asked about type of lighting in the TRIME questionnaire, but one social housing organisation from the Netherlands mentioned to an open question that they use LED lighting in the communal spaces of their dwellings. Two of respondents (in the UK and the Netherlands) mentioned replacement of regular lighting to LED lighting as one of the most effective measures to increase the energy efficiency of dwellings.

3.1.2 Organisational policies
Although the type of organisation of social housing organisations varies widely per country, there are also similarities. For example, the questionnaire shows that almost all social housing organisations take energy efficiency into account when purchasing new heating, cooling, hot water and/or ventilation devices. Further maintenance requirements, costs and user friendliness are also aspects that are often taken in consideration by the surveyed SHOs, and life cycle costs are less commonly considered. Almost all surveyed SHO obtain advice from external advisers, with the architect and the MEP consultant being the most common. Besides external advisors, many of the surveyed SHOs indicate that they use an internal expert. The majority of the surveyed SHOs pay extra attention to the commissioning and programming of their building devices, primarily for the heating system. The majority of the surveyed SHO stock in Spain, France and the UK pay extra attention to the commissioning and programming of hot water devices. The commissioning and programming of ventilation system is common, except for the Spanish SHOs, one of which indicated that they pay extra attention to the commissioning of the ventilation system.
Twenty of the 26 surveyed SHOs have the intention to invest in more energy efficient devices for cooling, heating, hot water and/or ventilation in future. SHOs replace the building installations primarily when the device is broken or
when they have found a more cost effective alternative. The maintenance contract and warranty period is not mentioned as a reason for the surveyed SHO to replace devices.

3.1.3 Belgium
Belgian housing stock consists of more than 5 million dwellings, 6.5% of those being social housing. This is a relatively small amount compared to other European countries. (IZA, 2013). The information below shows some basic information about social housing organisations in Belgium, based on the report Social housing in the EU (IZA, 2013) and the website www.housingeurope.eu (housingeurope, 2010)

Mission: Providing decent housing for low income household
Eligibility: Income ceilings and no housing property (combined with the household size) + target groups
Priority: Additional priority criteria based on urgency of needs
Type of providers: Local authority, Independent public body/public owned company, Other private non-profit
Type of public support to financing social housing: Grants and public guarantees from the region
Sale of social rental dwellings: right to buy; No sale of rental social housing allowed
Social housing rents and social allowance: income based rent

The energy efficiency of the Belgium housing stock can be visualized in energy labels

![Energy Labels](image)

Figure 3 Distribution energy label Belgium (Braga and Palvarini, 2013)

The majority of the Flemish respondents on the TRIME questionnaire note that they aim to achieve the goals set by the Flemish government in “Energierenovatie programma 2020” (energy renovation program 2020)(Vlaanderenisenergie, Unknown). The main goal of this program is to have energy efficient dwellings for all Flemish households by 2020. Measures to reach this goal within the existing building stock are post-insulation, replacement of single glazing with insulating double glazing and by replacement of older heating boilers in existing dwellings. Not all SHOs are confident that they will be able to achieve these goals, but most of them expect to get close to the goal by 2020.
**Energy policy – answers questionnaire (Belgium)**

- We created an energy upgrading program based on primarily quick wins. E.g. replace window frames, roof insulation and cavity wall insulation to reach the goals of 2020. Despite this program it is expected that the goals of 2020 will not be met.
- It is expected to achieve a 95% penetration rate of high energy efficient boilers and we expect that all dwellings will have roof insulation and new window frames + glazing.
- The goal is to meet the requirements from ERP 2020. It is expected that all requirements from the ERP2020 will be met and additionally façade insulation for all dwellings.
- The goal is to provide double glazing, high efficiency boilers and roof insulation to all dwellings by the end of 2020. It is expected that 85% of goal will be reached by 2020.
- The goal is to meet the guidelines VMSW by the end of 2020 and it is expected that this goal will be met within this timeframe. (Belgium)
- The goal is to have all dwellings equipped with double glazing, high efficiency boilers and roof insulation by the end of 2020, it is expected that we will be able to meet these goals.

**Energy efficiency investment plans – answers questionnaire (Belgium)**

- We will invest more in energy efficient devices by combining this in the regular renovation program.
- We will invest more in energy efficient devices and we will continue our search for systems that are energy efficient but also not too expensive.
- We are engaged in several pilot projects e.g. Resilient 7 (EU), and Ecoren (FI). Additionally we test heat pumps in combination with smart grids and CHP. New ventilation systems are tested in Ecoren, with the aim to find the optimal ventilation system for SHO (energy efficient, low noise, user friendly and straightforward maintenance).
- New built dwellings should meet E-60. Existing buildings will be provided with wall insulation and condensing boiler.
- We are planning to hire someone with this as a job description.

**Replacement plans related to energy efficiency – answers questionnaire (Belgium)**

- We are replacing all electrical heating systems and we are installing ventilation boxes (type c).
If we replace a device we choose for a more energy efficient alternative e.g. HR 107 combi boiler with energy efficient circulation pomp and DC ventilation unit. Additionally we have a replacement plan for kitchen geysers mainly to prevent health risks.

3.1.4 France
French housing stock consists of more than 28 million dwellings, 17.4% of those dwellings are social housing stock. This is average compared to other European countries (housingeurope, 2010). The information below shows some basic information about social housing organisations in France, based on the report Social housing in the EU (IZA, 2013) and the website www.housingeurope.eu (housingeurope, 2010)

**Mission:** Housing households under a certain income ceiling and increasing social mix

**Eligibility:** Income ceilings

**Priority:** DALO established priority access for homeless people and others based on urgency needs

**Type of providers:** independent public body/public owned company, Co-operative, Other private non-profit

**Type of public support to financing social housing:** Grants from state and/or local authorities; Public loans from CDC through Livret A

**Sale of social rental dwellings:** Sale to sitting tenants allowed

**Social housing rents and social allowance:** Cost-based rent/ Fixed rent ceiling(s) + housing allowances

The respondents from France mention the energy performance certificate in their energy saving policies. In a majority of cases the goals is to renovate buildings with and energy label E, F or G. Many of them did not answer the question about the expected energy saving.
Energy policy – answers questionnaire (France)

- 75% of the houses have an energy label E, F or G. The aim is to renovate the collective dwellings to label C (104 kWh primary energy per meter per year) and the individual dwellings also to a label C (150 kWh primary energy per meter per year). Additionally we aim to build 30 passive buildings (1000 dwellings)
- An overall energy reduction in 2020 of 20% compared to 2010
- Renovate the existing buildings with an E, F, or G label to dwellings with a C label, if this is possible. And new buildings with a minimum HPE
- Renovate houses with an E, F or G label and optimize the maintenance contract heating/ domestic hot water collective and individual boilers
- Average primary energy consumption per meter per year of 230 kWh over the entire building stock.

Energy efficiency investment plans – answers questionnaire (France)

- VMC double flow DHW solar CAP
- Testing innovative systems: reflection on heat recovery and grey water systems
- Halve the ECS and Greenhouse gas emission
- We ask our technical advisers to review the exploitation costs of our existing facilities and to validate the proposed schematic diagrams and devices issued by architects and design departments for new buildings
- Especially for buildings with electric heating

Replacement plans related to energy efficiency – answers questionnaire (France)

- We replace older devices based on their lifetime with more energy efficient devices. (e.g. boilers are replaced after 15 years)
- We replace our boilers after 16 years and collective systems are replaced after 25 years on average
- Currently we do feasibility studies towards the replacement of individual gas appliances to collective appliances

3.1.5 Netherlands

Dutch housing stock consists of more than 7 million dwellings, 33% of those dwellings are social housing stock. This is a larger percentage compared to other
European countries (housingeurope, 2010). The information below shows some basic information about social housing organisations in the Netherlands, based on the report Social housing in the EU (IZA, 2013) and the website www.housingeurope.eu (housingeurope, 2010)

**Mission:** Housing low-income people and intermediate groups

**Eligibility:** Varying across regions and municipalities; currently income ceiling apply

**Priority:** Households on relatively lower incomes

**Type of providers:** Other private non-profit

**Type of public support to financing social housing:** Public guarantees from central government

**Sale of social rental dwellings:** Sale to sitting tenants allowed

**Social housing rents and social allowance:** Income-based rent/Value-based rent housing allowances

*Figure 5: Energy label distribution the Netherlands (leefomgeving, 2016)*

The Dutch respondents mention different energy saving goals e.g. 20% CO2 reduction; an average energy index of 1.25; installation of solar panels, a living expenses reduction of 10-15%; and renovation of all dwellings with an F/G energy label. Two social housing Organisations mention that the main goal to achieve a reduction of living expenses for their tenants.

**Energy policy – answers questionnaire(Netherlands)**

- The energy efficiency vision should be finished in 2016. This vision will be based on the assignment from several municipalities. Due to the introduction of the “Herzieningswet” we should develop a vision within the triangle of municipality, SHO and tenants. In preparation of this we are engaged in a diversity of pilot project with a sustainability theme (not only energy, but also circular economy). It is expected that a sustainability vision is completed by 2020, choices are made and adjusted with stakeholder and sustainability should be an important point on the agenda.
- 20% CO2 reduction and we aim for no dwellings with an energy label of F and G. Up until now a sustainability vision has been developed, choices have been made and adjusted with our stakeholder. It is expected that 20% CO2 reduction will be met but not all F and G label dwellings will be renovated.
- Our organization carries out a “living expenses policy”. Each measure we do should reduce the living expenses of the tenants. Further no specific goals,
mainly due to our specific housing stock (mainly student houses). A significant part of the regulations do not take student housing into account e.g. not all investments can be earned back with the rental fee (for both, dependent and independent student housing). Additionally the determination method does not result in a representative image (e.g. a new built building with a collective heat pump resulted in a B/C label). Subsidy programs are not always applicable on the older independent student housing stock. We expect living expenses reduction (provided that building-related systems will be excluded from the “warmtewet”) and an additional saving of 10 – 15% by education and awareness of behaviour. A broader legislation to cover the cost-effective measures within the rent or serve cost the energy reduction could expedite. I expect possible energy savings of 25-50%

- The goal is an average energy index of 1.25 (no minimum requirements) and it is expected that this goal will be reached
- Goal is to equip the houses with solar panels and LED lighting. By 2020 it is expected that 500 dwellings will be equipped with solar panels and all building complexes will have LED lighting
- Goal is to translate all pilot projects from 2014-2016 into standardized sustainability targets. It is not our intention to do this alone. We aim to realize an extensive solution by performance agreements and with the help of stakeholders. Additionally regulations should also change. The goals focus on affordability. An intervention should result in an advantage for our customers. In the business case we will focus on cooperation and result should be the main focus

**Energy efficiency investment plans – answers questionnaire (Netherlands)**

- Due to internal policy and tightening regulations this is a logical result. In the Netherlands cooling is not (yet) required
- Forced by EPC (energy performance certificate). Lacking of incentives in current regulation for existing buildings
- There is explicitly search for measures that can reduce the total living expenses of the tenant, all measures are based on affordability. The living expenses have to be reduced or at least kept on an equal level

**Replacement plans related to energy efficiency – answers questionnaire (Netherlands)**

- We replace when technically necessary. If we replace we choose the best
suitable device (technical and energetic in combination with operating costs)

- We aim to replace all VR boilers to HR 107 boilers
- Replace all boilers to HR+ boilers
- Most important is placing combination boilers (if possible)

3.1.6 Spain

Spanish housing stock consists of more than 25 million dwellings, 2.4% of those dwellings are social housing stock, this is a relatively low amount compared to other European countries (housingeurope, 2010). The information below shows some basic information about social housing organisations in Spain, based on the report Social housing in the EU (IZA, 2013) and the website www.housingeurope.eu (housingeurope, 2010)

Mission: Housing low-income households and people in special needs

Eligibility: Income ceilings and no housing property

Priority: Disabled people and dependent persons; other priority criteria are established by the Comunidades autónomas on the basis of local situation

Type of providers: Local authority, Independent public body/public owned company, Co-operative Private for profit

Type of public support to financing social housing: Interests rates subsidies and public guarantees from central government; Complementary funding (grants) from the regional governments

Sale of social rental dwellings: Sale to sitting tenants allowed

Social housing rents and social allowance:

Figure 6: Energy label distribution (de Ayala et al., 2015)

The Spanish respondents note that their energy saving policy is based on the regulations set by the government Sostenibilidad Energetica en la Administration Vasca para 2017 (sustainable energy act in 2017 of the Basque Administration). The Basque country has set the reduction target for 2030 of at least 40% compared to the Green House Gas emission of 2005, and the saving
targets for 2050 are at least 80%.

### Energy policy – answers questionnaire (Spain)

- **Meet the building regulations of nearly zero energy consumption**
- **Continuous improvement**
- **In 2020 we aim to build only nearly zero energy buildings, as required by “Sostenibilidad Energética en la Administración Vasca para 2017” (sustainable energy act in 2017 of the Basque Administration)**

### Energy efficiency investment plans – answers questionnaire (Spain)

- **The intention is to equip new buildings with improved energy efficiency systems. We are currently considering air heat pumps, solar panels and a balanced ventilation system with heat recovery for a project. Additionally we have a future project that will have how water supply and heating via a biomass plant for the whole neighbourhood**

### Replacement plans related to energy efficiency – answers questionnaire (Spain)

- **No responses**

#### 3.1.7 United Kingdom

The housing stock of the United Kingdom contains almost 28 million dwellings, 18.2% of those dwellings are social housing stock, this is a relatively low amount compared to other European countries (housingeurope, 2010). The information below shows some basic information about social housing organisations in United Kingdom, based on the report Social housing in the EU (IZA, 2013) and the website [www.housingeurope.eu](http://www.housingeurope.eu) (housingeurope, 2010)

**Mission:** Housing people in need

**Eligibility:** Persons/households in need and with residential link to the municipality

**Priority:** Priority to homeless and others based on urgency of needs

**Type of providers:** Local authority, Independent public body/public owned company, Co-operative, Other private non-profit, Private for profit

**Type of public support to financing social housing:** Grants from government

**Sale of social rental dwellings:** Right to buy

**Social housing rents and social allowance:** Value-based rent + Housing allowances

The respondents from the UK have primarily based their energy saving policy on the EPC (Energy Performance Certificate) and SAP Score (Standard Assessment Procedure, this methodology is used by the UK Government to assess and compare the energy and environmental performance of dwellings)
Energy policy – answers questionnaire (United Kingdom)

- A minimum of EPC 'C' by 2020 it is expected that an upgrading of all EPC band F&G properties will be achieved where possible
- The goal is to achieve a SAP Score of 70 on average across the housing stock. A 10% energy consumption reduction in our offices by 2020 is expected to be reached (against a 2013 baseline)
- We are in the process of deciding on this. It is difficult to say something about the expected savings because the budgets are uncertain
- Establish that a SAP score of 65 will become the aspirational standard for our stock.

Identify sources of funding for renovation works and look at how funding can be maximized.
Propose how programs of work can be planned and implemented.
It is expected that a SAP score will be established and implemented in a programme of renovating older properties

Energy efficiency investment plans – answers questionnaire (United Kingdom)

- Currently reviewing specification for new build properties and replacements across older stock
- Working on networking Building Management Systems on our estates
- We do however our budgets are uncertain
- Replacement plan for heating, cooling, hot tap water and ventilation devices, specifically to increase energy efficiency
- yes, solar thermal, PV, CHP

Replacement plans related to energy efficiency – answers questionnaire (United Kingdom)

- Replacement with LED light fittings
3.2 Barriers
The possible barriers for social housing organisations as identified in the literature study (Section 2.3) were presented to the social housing organisations in the questionnaire, and the respondents on the questionnaire were asked to indicate which barriers they recognise to get an indication of the importance and frequency of occurrence of the barriers in practice. The results are explained in this section.

The possible barriers can be divided in three main categories:

- Technical barriers
- Financial barriers
- Organisational barriers

3.2.1 Technical barriers
Table 2 shows the technical barriers that were found in literature and the number of respondents that recognise these barriers. All technical barriers mentioned in the questionnaire were recognised at least once. The technical limitations of the existing building stock is the most recognised, followed by the planning restrictions towards the renovation of heritage buildings and the contractor who is not always familiar with the most recent energy efficient solutions. Only three of the 27 responding social housing organisations indicate that they do not always invest in the most energy efficient building installations because they want to keep the same brand. The housing organisations from the UK recognise the most barriers, followed by the Flemish, French, Dutch and Spanish social housing organisations.
Table 2 technical barriers in order of importance

<table>
<thead>
<tr>
<th>Technical barriers</th>
<th>Number of respondents that recognise the barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Technical limitations of existing building stock (Atanasiu et al., 2011);</td>
<td>15</td>
</tr>
<tr>
<td>2. Planning authorities pose often restrictions towards the retrofit of heritage buildings. Only a limited amount of retrofit measures are suited for these types of buildings (Atanasiu et al., 2011).</td>
<td>10</td>
</tr>
<tr>
<td>3. The contractor is not always familiar with the most recent energy efficient solutions due to the high pace of the solutions are developed. (Atanasiu et al., 2011)</td>
<td>10</td>
</tr>
<tr>
<td>4. Professionals (architect, MEP-consultant or other independent advisors) are not always up to date with the most energy efficiency solutions due to the high pace new solutions are developed (Atanasiu et al., 2011)</td>
<td>9</td>
</tr>
<tr>
<td>5. Too often the focus is on individual products instead of integrated renovation plans; (Atanasiu et al., 2011)</td>
<td>8</td>
</tr>
<tr>
<td>6. Long period of testing and development before innovative solutions gain approval for widespread application in buildings (Donkelaar et al., 2006)</td>
<td>5</td>
</tr>
<tr>
<td>7. Lack of information on the long-term failure risks that could occur in energy efficient renovation dwellings</td>
<td>4</td>
</tr>
<tr>
<td>8. Lack of knowledge and experience in social housing organisations about new energy efficient technologies (Atanasiu et al., 2011)</td>
<td>4</td>
</tr>
<tr>
<td>9. SHOs often want to keep the same brand/device in their building stock to keep the maintenance work clear (Meijer et al., 2009, Itard et al., 2008);</td>
<td>3</td>
</tr>
</tbody>
</table>
3.2.2 Financial barriers

Table 4 shows the financial barriers that were found in literature and the number of respondents that recognise these barriers. The most frequently recognised financial barrier for the responding social housing organisations is the lack of funds (Atanasiu et al., 2011). The barrier that ambitious retrofits require more funding upfront compared to common retrofits. The barrier that ambitious renovations require more funding upfront compared to the common renovations and the fact that social housing organisations make the investments but do not gain the benefits from these investments are the second and third most recognised financial barriers (Atanasiu et al., 2011). Higher insurance costs because of the uncertainty of new techniques are not recognised by any of the respondents. In the UK, the competing purchase decisions is frequently mentioned, e.g. tenants appreciate a new kitchen more than increased insulation. One Dutch respondent mentioned that it is not allowed to increase the rent, while others mentioned to use rent increases to cover the costs.

Other barriers that were mentioned by the responding social housing organisations were: mutated buildings have to be assigned appropriately; third parties are not willing to invest anymore because it is no longer “their” neighbourhood; energy suppliers are willing to invest but only if long term contracts are agreed; warranties can only be given if the energy prices are fixed for a longer period of time and that is not possible in a flexible energy market with freedom of choice.

The social housing organisations in the UK recognise the most financial barriers, followed by the Flemish, France, Dutch and Spanish social housing organisations.
### Table 4 financial barriers in order of importance

<table>
<thead>
<tr>
<th>Financial barriers</th>
<th>Number of respondents that recognise the barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lack of funds (Atanasiu et al., 2011)</td>
<td>20</td>
</tr>
<tr>
<td>2. The most ambitious renovations will require more funding upfront compared to the common renovations. With a tight budget it’s likely that corporations will compromise on spending on energy efficient measures. (Atanasiu et al., 2011)</td>
<td>17</td>
</tr>
<tr>
<td>3. The social housing organisation makes the investment but does not gain the benefits from the investment. This problem is known as: ‘split incentive barrier’, ‘landlord/tenant barrier’, ‘investor/user barrier’, or ‘principal/agent barrier’. (Atanasiu et al., 2011, Cadima, 2009)</td>
<td>16</td>
</tr>
<tr>
<td>4. Competing purchase decisions, investments in energy efficiency are not always considered the most important/popular investment for a social housing organisation; (Atanasiu et al., 2011)</td>
<td>11</td>
</tr>
<tr>
<td>5. The energy efficiency measures are not reflected in the market price of the building, while the measures taken are often not visible (Meijer et al., 2009, Atanasiu et al., 2011)</td>
<td>10</td>
</tr>
<tr>
<td>6. Tenants are not willing to invest in the dwelling themselves because they believe that the main beneficiary of the investments is the owner of the building or they consider this a task of the Social housing organisation (Atanasiu et al., 2011)</td>
<td>7</td>
</tr>
<tr>
<td>7. Due to changing policies, it is more difficult to obtain loans for social housing organisations (Atanasiu et al., 2011)</td>
<td>5</td>
</tr>
<tr>
<td>8. Future energy prices are unclear, and actual return costs are therefore difficult to calculate. (Atanasiu et al., 2011)</td>
<td>5</td>
</tr>
<tr>
<td>9. Higher insurance cost because of the uncertainty of new</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 5 Overview results questionnaire financial Barriers per country

<table>
<thead>
<tr>
<th>Financ. barrier</th>
<th>Total (n=27)</th>
<th>Flanders (n=6)</th>
<th>France (n=6)</th>
<th>Netherlands (n=6)</th>
<th>Spain (n=4)</th>
<th>UK (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>74%</td>
<td>67%</td>
<td>83%</td>
<td>50%</td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>63%</td>
<td>67%</td>
<td>83%</td>
<td>33%</td>
<td>50%</td>
<td>80%</td>
</tr>
<tr>
<td>3</td>
<td>59%</td>
<td>100%</td>
<td>83%</td>
<td>67%</td>
<td>0%</td>
<td>20%</td>
</tr>
<tr>
<td>4</td>
<td>41%</td>
<td>33%</td>
<td>33%</td>
<td>33%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>5</td>
<td>37%</td>
<td>67%</td>
<td>0%</td>
<td>50%</td>
<td>25%</td>
<td>60%</td>
</tr>
<tr>
<td>6</td>
<td>26%</td>
<td>0%</td>
<td>50%</td>
<td>33%</td>
<td>0%</td>
<td>20%</td>
</tr>
<tr>
<td>7</td>
<td>19%</td>
<td>33%</td>
<td>17%</td>
<td>17%</td>
<td>0%</td>
<td>20%</td>
</tr>
<tr>
<td>8</td>
<td>19%</td>
<td>17%</td>
<td>17%</td>
<td>17%</td>
<td>0%</td>
<td>40%</td>
</tr>
<tr>
<td>9</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>37%</td>
<td>43%</td>
<td>41%</td>
<td>33%</td>
<td>17%</td>
<td>49%</td>
</tr>
</tbody>
</table>

3.2.3 Organisational barriers

Table 6 shows the organisational barriers that were found in literature and the number of respondents that recognise these barriers. The problem that the buildings are often in use is recognised the most by the responding social housing organisations. Closely related to this aspect is the difficulty to reach the minimum occupant consensus in advance of a renovation process. Similar to the technical barriers, the organisational barriers are most frequently recognised by the social housing organisations of the UK, followed by the Flemish, French, Dutch and Spanish organisations.
Table 6 organisational barriers in order of importance

<table>
<thead>
<tr>
<th>Organisational barriers</th>
<th>Number of respondents that recognise the barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Existing buildings are often in use</td>
<td>17</td>
</tr>
<tr>
<td>2. It is difficult to reach the 70% consensus (which has to be reached in a majority of the European countries) among the occupants because:</td>
<td>13</td>
</tr>
<tr>
<td>• Occupant often refuse to cooperate with renovations because it changes the appearance of the dwelling</td>
<td></td>
</tr>
<tr>
<td>• Occupants often refuse to cooperate with renovations due to fear of rent increase;</td>
<td></td>
</tr>
<tr>
<td>• Occupants often refuse to cooperate with renovations due to expected troubles and inconvenience;</td>
<td></td>
</tr>
<tr>
<td>• Occupants are not willing to cooperate due to lack of trust in social housing organisations;</td>
<td></td>
</tr>
<tr>
<td>3. Lack of a common understanding about energy efficiency goals</td>
<td>6</td>
</tr>
<tr>
<td>4. Building regulations are mainly focussing on new buildings and not on existing buildings</td>
<td>6</td>
</tr>
<tr>
<td>5. If building codes are too prescriptive, they could hinder innovations</td>
<td>4</td>
</tr>
<tr>
<td>6. Advisors and designers are often involved too late in the process</td>
<td>2</td>
</tr>
<tr>
<td>7. Lack of time for the design process</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 7 Overview results questionnaire organisational Barriers per country

<table>
<thead>
<tr>
<th>Org. barrier</th>
<th>Total</th>
<th>Flanders</th>
<th>France</th>
<th>Netherlands</th>
<th>Spain</th>
<th>UK</th>
</tr>
</thead>
</table>
3.3 Solutions
Possible solutions to overcome barriers that were found in literature (see section 2.4) can be divided in the three categories:

- Technical solutions
- Financial solutions
- Organisational solutions

The solutions were listed in the questionnaire, and the responding SHOs indicated which solution is being used in their organisation. The results are presented in this section.

3.3.1 Technical solutions
Table 8 shows the technical solutions that were found in the literature and the number of respondents that use these solutions in their organisation. The solution to combine the regular maintenance work with the implementation of energy saving measures is the most frequently recognised. The use of BIM (Building Information Model) is only implemented by three of the responding social housing organisations. The Dutch responding social housing organisations apply the most technical solutions, followed closely by the Flemish, French and housing organisations from the UK.

Table 8 Technical solutions in order of importance

<table>
<thead>
<tr>
<th>Technical solutions</th>
<th>Number of respondents that use the solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Combine regular maintenance with implementation of energy saving measure. (Donkelaar et al., 2006)</td>
<td>17</td>
</tr>
<tr>
<td>2. Gather the experience from previous projects and document those structurally. These can be used as a reference guide</td>
<td>10</td>
</tr>
</tbody>
</table>
3. Organise energy performance based tenders (Atanasiu et al., 2011) 8

4. Organise energy performance based tenders (Donkelaar et al., 2006) 5

5. Make use of BIM (Building information model) (Häkkinen and Belloni, 2011) 3

Table 9 Overview results questionnaire - Technical Solutions

<table>
<thead>
<tr>
<th>Technical solutions</th>
<th>Total (n=27)</th>
<th>Flanders (n=6)</th>
<th>France (n=6)</th>
<th>Netherlands (n=6)</th>
<th>Spain (n=4)</th>
<th>UK (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>63%</td>
<td>67%</td>
<td>67%</td>
<td>83%</td>
<td>50%</td>
<td>40%</td>
</tr>
<tr>
<td>2</td>
<td>37%</td>
<td>33%</td>
<td>67%</td>
<td>17%</td>
<td>25%</td>
<td>40%</td>
</tr>
<tr>
<td>3</td>
<td>30%</td>
<td>33%</td>
<td>0%</td>
<td>17%</td>
<td>25%</td>
<td>80%</td>
</tr>
<tr>
<td>4</td>
<td>19%</td>
<td>17%</td>
<td>33%</td>
<td>33%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>5</td>
<td>11%</td>
<td>17%</td>
<td>0%</td>
<td>33%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>32%</td>
<td>33%</td>
<td>33%</td>
<td>37%</td>
<td>20%</td>
<td>32%</td>
</tr>
</tbody>
</table>

3.3.2 Financial solutions

Table 10 shows the financial solutions that were found in the literature and the number of respondents that use these solutions in their organisation. Although the literature suggested that only in a few countries it is allowed to increase the rent to finance the energy renovation, there were 10 social housing organisations from Flanders, France and the Netherlands that indicated to finance their renovations with this measure. Seven of the 27 responding social housing organisations indicated that they give living expenses guarantee after the renovation. Although one respondent from the Netherlands replied that the energy label is not yet reflected in the market price, there are some organisations located in other countries that disagree and state that the energy label is reflected in the market price.

None of the responding social housing organisations made collective agreements with the energy supplier. From the responding social housing organisations, the French use the most financial solutions, followed by the Dutch, Flemish, Spanish and organisations from the UK.

Table 10 Financial solutions in order of importance
<table>
<thead>
<tr>
<th><strong>Financial solutions</strong></th>
<th><strong>Number of respondents that use the solution</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Conventional financing: tenants will be completely/partly charged for the investment by means of rent increase. (Donkelaar et al., 2006)</td>
<td>10</td>
</tr>
<tr>
<td>2. Living Expenses Guarantee: Housing association gives tenants a guarantee that the total living expenses (consisting of the rent and secondary expenses like energy costs, cable and telephone) during a certain period of time will not increase more than a common inflation rate. This removes the rent increase barriers for tenants. (Donkelaar et al., 2006)</td>
<td>7</td>
</tr>
<tr>
<td>3. The energy rating will result in an increased market value of the dwelling after renovation (Häkkinen and Belloni, 2011)</td>
<td>5</td>
</tr>
<tr>
<td>4. Energy Performance Contract: Investments and accompanying services regarding the realization and monitoring of energy saving measures are financed from the generated savings on energy consumption. The contract is closed between tenants, the housing association and an external party for a longer period (approximately 10 years). The energy performance contract is mostly focused on (collective) energy supply with accompanying energy management/administration. (Donkelaar et al., 2006, Itard et al., 2008)</td>
<td>2</td>
</tr>
<tr>
<td>5. Energy accounts through the housing cooperative: A housing association invests in refurbishment and at the same time agrees on a collective agreement with the energy supplier (negotiating lower rates than a single tenant could get). Tenants will pay the energy bill to be cooperative. As a result, they will get their rent and energy costs on one bill, showing rent increase and energy cost decrease (Donkelaar et al., 2006)</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 11 Overview results questionnaire - Financial Solutions

<table>
<thead>
<tr>
<th>Financial solutions</th>
<th>Total</th>
<th>Flanders</th>
<th>France</th>
<th>Netherlands</th>
<th>Spain</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>37%</td>
<td>17%</td>
<td>83%</td>
<td>67%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>26%</td>
<td>50%</td>
<td>50%</td>
<td>17%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>3</td>
<td>19%</td>
<td>17%</td>
<td>33%</td>
<td>0%</td>
<td>25%</td>
<td>20%</td>
</tr>
<tr>
<td>4</td>
<td>7%</td>
<td>0%</td>
<td>17%</td>
<td>17%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>5</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>17%</td>
<td>17%</td>
<td>37%</td>
<td>20%</td>
<td>5%</td>
<td>4%</td>
</tr>
</tbody>
</table>

3.3.3 Organisational solutions

Table 12 shows the organisational solutions that were found in the literature and the number of respondents that use these solutions in their organisation. Convincing the tenants to renovate their dwelling with the argument that not only their energy bill will reduce but that their comfort will increase is by far the most applied organisational solution by the responding social housing organisation. French social housing organisations use the most organisational solutions, the Dutch and Spanish social housing organisations use the least organisational solutions.

Table 12 Organisational solutions in order of importance

<table>
<thead>
<tr>
<th>Organisational solutions</th>
<th>Number of respondents that use the solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tenants are expected to be more open towards renovation when the increased comfort as a result of renovation is clear for them (Meijer et al., 2009, Atanasiu et al., 2011, Donkelaar et al., 2006)</td>
<td>22</td>
</tr>
<tr>
<td>2. Consultants and designers should be involved early in the process (Donkelaar et al., 2006, Häkkinen and Belloni, 2011)</td>
<td>13</td>
</tr>
<tr>
<td>3. Renovation could be combined with upgrading the neighbourhood (Donkelaar et al., 2006)</td>
<td>8</td>
</tr>
<tr>
<td>4. Introduction of the building energy rating should result in more awareness under the tenants (Atanasiu et al., 2011, Itard et al., 2008)</td>
<td>8</td>
</tr>
<tr>
<td>5. Education programs could make the social housing</td>
<td>6</td>
</tr>
</tbody>
</table>
organisations more aware of the importance of energy efficiency (Itard et al., 2008, Meijer et al., 2009);

| 6. Projects that are well documented should be distributed under the experts and social housing organisations in order to stimulate the execution of future projects (Tommerup and Svendsen, 2006, Donkelaar et al., 2006) | 6 |

7. Publicity campaign (Itard et al., 2008) | 3 |

*Another solution suggested by one of the responding social housing organisations is: to influence the policymakers and to convince them that the current regulations do not suit their energy saving targets. (NL)*

<table>
<thead>
<tr>
<th>Table 13 Overview questionnaire results - Organisational Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational solutions</td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

3.3.4 Overall findings
The housing organisations in the UK recognise the most barriers overall and the fewest solutions. The Spanish social housing organisations recognize the fewest barriers, but they also do not use many solutions. The Dutch housing organisations recognise only few barriers, but they use relatively many solutions. The French social housing organisations list relatively many barriers, but they use relatively many solutions.

3.4 Most and least effective energy saving measures
At the end of the survey, the respondents were asked to name the most and the least effective energy saving measure they have used/ are using in their organisation. There was no consensus on the most or least effective measures among the social housing organisations, e.g. roof insulation is mentioned both as
most effective measure and least effective measure. The measures that are mentioned by the responding SHOs as the most and least effective energy saving measures are primary technical measures such as insulation, upgrading of boilers and high efficiency glazing. Besides technical measures, the focus on behaviour change (the Netherlands and Flanders) and performance contracts (France) are mentioned as effective energy efficiency measures.

The Flemish, French and social housing organisations mention insulation as effective measures, while in the Netherlands the installation of energy efficient gas boilers is considered to be the most effective. Insulation is listed twice as least effective measure by Dutch social housing organisations and once by a housing organisation from the UK. Further energy efficient measures that housing associations list as less effective are more complex building installations such as biomass boilers, heat pumps, ventilation systems, Solar panels and LED lighting are mentioned as effective measures. According to one respondent from the UK, the combination of low maintenance costs and energy efficiency cannot go together.

Table 14 Results questionnaire - most effective and least effective solutions to overcome barriers that prevent social housing organisations to invest in energy renovations

<table>
<thead>
<tr>
<th>Most effective</th>
<th>Least effective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flanders</strong></td>
<td><strong>Flanders</strong></td>
</tr>
<tr>
<td>• Attic insulation in combination with social projects are the most cost effective</td>
<td>• Cogeneration plants. The electricity gains are not in proportion with the required investments. Therefore we look at combinations with heat pumps etc.</td>
</tr>
<tr>
<td>• Switching from electrical heating to heating with gas</td>
<td>• Ventilation installations</td>
</tr>
<tr>
<td>• Roof insulation and better insulating windows</td>
<td></td>
</tr>
<tr>
<td><strong>The Netherlands</strong></td>
<td><strong>The Netherlands</strong></td>
</tr>
<tr>
<td>• The most effective measure for the SHO is the replacement of boilers on the regular replacements moment.</td>
<td>• Investments in insulation and other measures that are not regular</td>
</tr>
<tr>
<td>• Influencing behaviour large scale (TELI 2008) and small scale (Student Energy Race) education/information projects have an enormous</td>
<td>• District heating</td>
</tr>
<tr>
<td></td>
<td>• Insulation of ground floor</td>
</tr>
<tr>
<td></td>
<td>• Roof insulation</td>
</tr>
</tbody>
</table>
- (lasting) effect
  - Replacement of VR, CV. Boilers by HR 107 boiler. Cavity insulation attic/roof insulation and the replacement of single glazing by HR++ glazing. Biggest influence is than that you are enable to name the renovation year.
  - Solar panels and LED lighting
  - Replacement of VR boilers by HR boilers, results in a improved energy label.

<table>
<thead>
<tr>
<th>Energy saving measures that do not result in an improved energy label</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Energy saving measures that do not result in an improved energy label</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Improve the insulation of the building (façade, roof, window)</td>
</tr>
<tr>
<td>• Equip all dwellings with low energy lightbulbs and aerators in taps.</td>
</tr>
<tr>
<td>• Energy performance contracts. A contract with the obligation to have a certain €/m3 heating costs and hot tap water costs etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>• No responses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td>• No responses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td>• No responses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Insulation, double glazing and boiler upgrades</td>
</tr>
<tr>
<td>• LED light bulb replacement. BMS (building maintenance system) remote control is expected to be successful.</td>
</tr>
<tr>
<td>• External Wall Insulation to System Built properties and Modern Condensing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Communal Heating Biomass Exhaust Air Heat Pumps</td>
</tr>
<tr>
<td>• Communal boiler systems unless they are close to a supply of low cost low carbon energy</td>
</tr>
<tr>
<td>• Air Source Heat Pumps</td>
</tr>
</tbody>
</table>
Combi Boilers

- air source heat pumps
- insulation measures (UK)
- cavity wall insulation and loft insulation

mostly down to a lack of understanding on how the operating systems by the end users

- not sure
- High level of insulation of the building envelope
- Combination of low maintenance costs with sustainable performance result in increased costs.

Based on the outcomes of the TRIME questionnaire possible relationships between particular questions were investigated, e.g. a relationship between type of building installations and energy policy; a relationship between certain barriers and the type of building installations or the existence of an energy saving policy etc. In this cross sectional analysis, no significant relationships were found. This could mean that there is no relationship, but the lack of relationships could also be caused by the limited amount of responses on the TRIME questionnaire.

3.5 Conclusions

Based on the findings of the literature study and the TRIME questionnaire it can be concluded that there are barriers that are specific per social housing organisation and barriers that are existing in all social housing organisation regardless of their size or location. The measures they use to overcome those barriers are as diverse are the mentioned barriers. Some energy saving measures are rated as most effective by one organisation but as least effective by another. Therefore, before implementing energy saving measures, the organisation should first analyse which measures and best practice are the most effective for them and their tenants.
4 Barriers and solutions – in-depth interviews

Based on the findings of the literature study and questionnaire, in-depth interviews were taken with four TRIME social housing organisations. The aim of the interview was to identify the barriers that social housing organisations experience when investing in energy efficiency measures and the solutions they use to overcome those barriers. This chapter shows the most important learnings of these interviews.

4.1 Renovation types

The interviewed social housing organisations distinguish three different types of energy renovations:

- **Deep renovation** The term Deep renovation refers to dwellings with poor technical conditions that are renovated to an energy label A or B. In the majority of cases the tenants have to leave their house for a period to allow construction work to take place.
- **2 label step renovation** This type of renovation aims to increase the energy efficiency of a house with at least two label steps while the house is occupied or after mutation.
- **Single measure renovation** The single measure renovation approach is primarily used when a component of a building hasn’t been replaced or upgraded for a certain period of time (or when a component is not functioning as it should).

4.2 Barriers

The interviewed social housing organisations mentioned several barriers. Main barriers are a lack of budget. Governmental subsidies are in some countries only available for the houses with the lowest energy label, if a housing organisation has a building stock that is in between they don’t get subsidies to do energy renovations. Also they note that renovating heritage dwellings is often more expensive than re-building.

Another barrier mentioned is the willingness of the tenants to cooperate and sometimes temporarily decant. Because deep renovations are often not possible when the dwelling is occupied the occupants have to decant temporarily, this is not always possible, which results in more small and less intrusive measures that can be executed when the dwelling is occupied. Deep renovations only happen by these organisations if a dwelling is mutated. Disadvantage is that it is not possible to renovate an entire apartment block at once.

Building regulations can also be a barrier for innovative solutions.

The size of the dwelling can hamper the possibilities for energy renovations. Some dwellings only have a floor area of 30-40 m², and insulation on the inside of the walls will result in a significant decrease of the floor area.

The energy performance calculation software is sometimes lagging behind. For example, a collective heating system was in a previous software system rated less energy efficient than individual systems. This was changed in more recent
versions of the software, but it does not help social housing organisations to find the most energy efficient renovation solutions.

4.3 Solutions
Despite the barriers toward energy renovation, the interviewed housing organisations still carry out energy renovations, although not always as many as desired.

- If a housing organisation has a large amount of similar dwelling types, the solution can be optimisation of the renovation approach for this type of dwellings.
- If the budget is reducing the possibility to renovate, the social housing organisation should consider other financing solutions. For example:
  o Reserve a budget for energy renovations in the start of the year;
  o Renovate after mutation to avoid problems with occupants;
  o Combine the renovation of pressing technical measures (e.g. foundation problems) with energy renovation measures.
  o If the opportunity comes up try to bring the dwellings up to the highest possible level. Don’t waste your chances
  o Increase rent after renovation (not in every country allowed or desired);
  o Attending European and national projects focussing on innovative energy renovation measures can help social housing organisations to find new and sometimes better solutions for energy renovations.
  o Keep in mind that you have to invest in order to learn;
  o Check if it is more efficient to demolish instead of renovate;
  o Follow the newest renovation closely e.g. hire a sustainability employer who keeps track of all new sustainability innovations (e.g. follow the development of hydrogen boilers for dwellings);
  o Energy efficiency measures do not only cost money. For example: Multifamily dwellings that are highly insulated and are airtight require less energy for heating, therefore it is a possibility to use an condensing gas boiler, that is normally used as an individual system, as a central heating system. Two boilers can heat 8 houses instead of one, which means that housing organisation only needs to purchase two boilers instead of 8 and also has to maintain only two boilers.
  o Focus not only on short term solutions but also/primarily on long term solutions
  o Try to keep your knowledge up to date although the market is changing rapidly
  o The airtightness of a building is important to reduce energy consumption for heating, always do a test after the construction to determine if the required airtightness is reached;
  o Energy performance contracting can help to stimulate the contractor to deliver the energy savings he promised.
  o Make a standard template for energy renovation measures per dwelling type, but always hire an expert to tailor the advice for the specific dwelling;
- Install the same brand as much as possible to keep the maintenance work consistent;
- Make a clear business case that shows that energy efficiency is not only a nice thing to do but also has a positive impact on your business;
- Not only apply the commonly known installations but also try alternatives.
5  Best practices – a result of literature survey, questionnaire and interviews

This chapter describes some of the best practice that were mentioned by the responding social housing organisations during the interviews and questionnaires, completed with information from literature. This chapter can be used as a starting point for social housing organisations to see what possible energy renovation measures are available. However, the best practice cover a wide range of possible renovation measures, varying from invasive renovation measures to non-invasive renovation measures. Moreover, there are more possible solutions on the market than described in this report.

5.1  Introduction

Best practice are chosen based on the answers in the TRIME questionnaire, on the question about the most and least effective energy efficiency measures that the responding social housing organisations have adapted in their housing stock (see section 3.4). Based on this information we choose the best practice:

- Glazing (5.2)
- Insulation (5.3)
- Heating systems (5.4)
- Ventilation systems (5.5)
- Solar panels (5.6)
- Energy performance contracts (5.7)

Each section gives the basic information about the technique and possible energy savings, followed by a description of the possible options and solutions, and ending with points of attention for the best practice.

In section 5.7, possible energy renovation concepts, especially net zero energy dwellings are described

5.2  Glazing

5 of the 27 respondents listed better (window) insulation as one of the most effective means to increase the energy efficiency of a dwelling. Two of the respondents mentioned an increased insulation level as an ineffective measure.

<table>
<thead>
<tr>
<th>Most effective</th>
<th>Least effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flanders</td>
<td>Flanders</td>
</tr>
<tr>
<td>• Roof insulation and better insulating windows</td>
<td></td>
</tr>
<tr>
<td>The Netherlands</td>
<td>The Netherlands</td>
</tr>
<tr>
<td>• Replacement of VR, CV. Boilers by HR 107 boiler. Cavity insulation attic/roof insulation and the replacement of single glazing by HR++ glazing. Biggest influence is than that you are enable to name the renovation year.</td>
<td>• Investments in insulation and other measures that are not common</td>
</tr>
<tr>
<td>France</td>
<td>France</td>
</tr>
</tbody>
</table>
Improve the insulation of the building (façade, roof, window)

- Insulation, double glazing and boiler upgrades
- Air source heat pumps insulation measures (UK)

The building envelope determines the energy exchange between outdoor and indoor and thus has a large influence on the overall energy performance of the building (Sozer, 2010). Window glazing is often one of the weakest spots in the thermal insulation of a building because of the lower heat resistance of glass, compared with an insulated wall. In a standard family dwelling, 10-20% of the total heat losses take place through the windows (Pacheco et al., 2012). With the glazing currently on the market, the window does not have to be the weakest link. The best performing windows can collect even more heat than they lose during the winter months (Holladay, 2010).

A better insulating glazing type will not only contribute to an energy consumption reduction but also to an increased indoor comfort. The temperature difference between the window surface and the indoor temperature will be smaller with better insulated windows and therefore there will be less cold draught than in a building with single glazing.

5.2.1 Possible options

There are different types of glazing; the U-value determines the insulation rate of the glazing types. Windows with a low U-value have the best insulation (Holladay, 2010):

- Single glazing: U-value = 5,8
- Double glazing: U-value = 2,8
- Super-insulating glazing: U-value = 1,1
- Triple glazing: U-value = 0,6

Since not all window frames are suited for each type of glazing, the window frame sometimes needs also to be replaced when the glazing type is changed. This means that you not only have to choose the type of glazing, but also the type of window frame. In general, window frames are made of timber, PVC or aluminum (with or without thermal breaks). In addition to the type of glazing, the type of window frame contributes to the total insulation rate of the building. Table 16 shows that timber frames insulate best, followed by PVC with several rooms.

Apart from different types of glazing there are choices of different coatings. A coating can help to make the glass more clear and get the maximum daylight and heating into the room. But there is also an option to reduce heat and glare from
the sun, to help keep rooms cool during sunny periods reducing the need for air conditioning.

**Table 16 U-value window frames and types of glazing (82.3, 2011)**

<table>
<thead>
<tr>
<th>Glazing frame</th>
<th>Wood U-value</th>
<th>PVC (one compartment)</th>
<th>PVC (several compartments)</th>
<th>Aluminium (without thermal break)</th>
<th>Aluminium (with thermal break)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single glazing</td>
<td>4,8</td>
<td>5,1</td>
<td>4,7</td>
<td>5,9</td>
<td>5,4</td>
</tr>
<tr>
<td>Double glazing</td>
<td>2,8</td>
<td>3</td>
<td>2,7</td>
<td>3,7</td>
<td>3,2</td>
</tr>
<tr>
<td>Super insulating glazing</td>
<td>1,8</td>
<td>2</td>
<td>1,7</td>
<td>2,6</td>
<td>2,2</td>
</tr>
<tr>
<td>Triple glazing</td>
<td>1,4</td>
<td>1,8</td>
<td>1,4</td>
<td>2,3</td>
<td>1,9</td>
</tr>
</tbody>
</table>

**5.2.2 Points of attention**

Figure 8 shows that the U-value is decreasing by each step of glazing type. But the difference between super insulating glazing and triple glazing is smaller than between single glazing and double glazing. This means that an upgrade of single glazing to double glazing will result in a higher energy saving than the upgrade of super-insulating glazing to triple glazing. Furthermore, triple glazing is currently much more expensive than double or super insulating glazing.

It is important to consider that not all window frames are suitable for all glazing types. This has primarily to do with the fact that double and triple glazing is much heavier than single glazing and the glass is often much thicker.

**Figure 8 U-value versus glazing type**

**5.3 Insulation**

8 of the 27 respondents mentioned better (window) insulation as one of the most effective means to increase the energy efficiency of a dwelling. Four of the respondents mentioned an increased insulation level as an ineffective measure.
Table 17 Most and least effective renovation measures – questionnaire results

<table>
<thead>
<tr>
<th>Most effective</th>
<th>Least effective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flanders</strong></td>
<td></td>
</tr>
<tr>
<td>- <em>Most effective: attic insulation in combination with social projects are the most cost effective</em></td>
<td><strong>Flanders</strong></td>
</tr>
<tr>
<td>- <em>Most effective: attic insulation in combination with social projects are the most cost effective</em></td>
<td></td>
</tr>
<tr>
<td>- <em>Roof insulation and better insulating windows</em></td>
<td></td>
</tr>
<tr>
<td><strong>The Netherlands</strong></td>
<td><strong>The Netherlands</strong></td>
</tr>
<tr>
<td>- <em>Replacement of VR, CV. Boilers by HR 107 boiler. Cavity insulation attic/roof insulation and the replacement of single glazing by HR++ glazing. Biggest influence is than that you are able to name the renovation year.</em></td>
<td>- <em>Investments in insulation and other measures that are not regular</em></td>
</tr>
<tr>
<td></td>
<td>- <em>Insulation of ground floor</em></td>
</tr>
<tr>
<td></td>
<td>- <em>Roof insulation</em></td>
</tr>
<tr>
<td><strong>France</strong></td>
<td><strong>France</strong></td>
</tr>
<tr>
<td>- <em>Improve the insulation of the building (façade, roof, window)</em></td>
<td></td>
</tr>
<tr>
<td><strong>UK</strong></td>
<td><strong>UK</strong></td>
</tr>
<tr>
<td>- <em>Insulation, double glazing and boiler upgrades</em></td>
<td>- <em>High level of insulation of the building envelope</em></td>
</tr>
<tr>
<td>- <em>External Wall Insulation to System Built properties and Modern Condensing Combi Boilers</em></td>
<td></td>
</tr>
<tr>
<td>- <em>cavity wall insulation and loft insulation</em></td>
<td></td>
</tr>
</tbody>
</table>

Based on the Trias Energetica principle, insulation is one of the first measures to start with. Building insulation reduces unwanted heat loss. A higher insulation rate (Rc value) results in a lower heat loss. The insulation rate of the dwelling is determined by the type of glazing, floor insulation, wall insulation and roof insulation. Insulation can be applied from the inside, outside and in the wall cavity.

Insulation will not only prevent unwanted heat loss, but it will also reduce the cold draught, which increases the comfort in the building.

**5.3.1 Possible options**

If you decide to insulate a building, you can choose to insulate the entire building envelope or you can insulate a part of the building e.g. roof, walls or floor.

Insulation can be applied on the inside or on the outside of the building, or in the wall cavity. The building characteristics will determine where the insulation can be best applied.
5.3.2 Points of attention

Insulation on the outside is easier to apply because the change on moisture problems is smaller, but this is not always possible, e.g. because of the heritage status of the building.

Insulating a building on the inside of the façade results in a cold façade (the façade is not exposed anymore to the inside temperature and will therefore change into a cold wall). This can result in cracks in brickwork.

The place of the insulation also influences the heat accumulation capacity of the building. Heavy buildings (built with stone or concrete walls and floors) accumulate a lot of heat in the walls, and thus heat up and cool down slowly. If you insulate a heavy building on the inside, it will start to behave as a lightweight building (a building with wooden walls and floors) and heat up and cool down quickly.

Insulation on the inside will result in a reduction of the living area, which can be undesirable in smaller dwellings.

5.4 Heating system

Table 18 Most and least energy renovation measures - questionnaire results

<table>
<thead>
<tr>
<th>Most effective</th>
<th>Least effective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flanders</strong></td>
<td><strong>Flanders</strong></td>
</tr>
<tr>
<td>• Switching from electrical heating to heating with gas</td>
<td></td>
</tr>
<tr>
<td><strong>The Netherlands</strong></td>
<td><strong>The Netherlands</strong></td>
</tr>
<tr>
<td>• The most effective measure for the SH0 is the replacement of boilers on the regular replacements moment</td>
<td></td>
</tr>
<tr>
<td>• Replacement of VR, CV. Boilers by HR 107 boiler. Cavity insulation attic/roof insulation and the replacement of single glazing by HR++ glazing. Biggest influence is that you are enable to name the renovation year.</td>
<td></td>
</tr>
<tr>
<td>• Replacement of VR boilers by HR boilers, results in a improved energy label</td>
<td></td>
</tr>
<tr>
<td><strong>UK</strong></td>
<td><strong>UK</strong></td>
</tr>
<tr>
<td>• Insulation, double glazing and boiler upgrade</td>
<td>• Communal Heating Biomass Exhaust Air Heat Pumps</td>
</tr>
<tr>
<td>• External Wall Insulation to System Built properties and Modern Condensing Combi Boilers</td>
<td>• Communal boiler systems unless they are close to a supply of low cost low carbon energy</td>
</tr>
<tr>
<td>• air source heat pumps insulation measures</td>
<td>• Air Source Heat Pumps mostly down to a lack of understanding on how the operating systems by the end users</td>
</tr>
</tbody>
</table>
The largest amount of the energy in most houses is used for heating. Therefore, it is important to reduce the amount of heating with the use of insulation, but the remaining heating demand should be generated as efficient as possible.

5.4.1 Possible options
Currently there are many different heating systems on the market. The most efficient heating system depends on the physical state of the dwelling and of the occupant characteristics and behaviour.

The most common **energy sources** for energy efficient heating systems are:

- Gas
- Electricity
- Wood pellets
- Biomass
- Solar heating
- Communal or district heating

Before deciding on a type of heating system, the available energy sources (gas, district heating) on the specific location need to be checked. Energy efficient heating systems are (efficiency given in percentages):

- **Gas condensing boiler**
  The gas condensing boiler is one of the most common heating systems in Europe. A gas condensing boiler distributes the heat via hot water, which releases heat as it passes through radiators or other devices in rooms throughout the house. The cooler water then returns to the boiler to be reheated. A boiler uses a pump to circulate hot water through pipes to radiators or plastic tubes in the floor (Milin et al., 2011a).
- **Micro CHP, combined heat and power (gas)**
  Similar to the condensing boiler, but besides generating heat, this boiler also generates electricity. This boiler is more efficient, but the purchase costs are much higher (duurzaamthuis).
- **Heat pump** (electricity/gas) 600%
  There are different types of heat pumps: air-source heat pumps (collects heat from air) and ground-source heat pumps (collects heat from ground). The generated heat can be distributed in the house via air or via water. Heat pumps can both heat and cool the house (SmarterHouse, 2015).
- **Pellet stove**
  A pellet stove generates heat by burning small wooden pellets. This system can be used as individual or as central heating system. The efficiency of a pellet stove is lower than the efficiency of a heat pump or condensing boiler, but since the pellets are made of recycled biomaterial or wood, it can be considered as a more environmental friendly way of heating (duurzaamthuis, 2015).
- **Solar heating**
  Solar heating system use solar energy to heat a heating fluid in roof-mounted systems, which transfer the heat directly to the interior space or to a storage system for later use. (U.S.departmentofEnergy, 2015)
- **Hybrid systems**
Because all systems have advantages and disadvantages, it is sometimes a better solution to combine different systems.

### Table 19 Heating systems

<table>
<thead>
<tr>
<th>Gas condensing boiler</th>
<th>Micro-WKK</th>
<th>Heat pump</th>
<th>Pellet stove</th>
<th>Solar heating</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="http://www.remeha.com/products/domestic-boilers/" alt="Image" /></td>
<td><img src="http://www.buildingservicesindex.co.uk/entry/40776/Baxi-Heating-UK/Baxi-Ecogen-domestic-microCHP-boiler/" alt="Image" /></td>
<td><img src="http://www.energysvc.com/heat-pump-tips/" alt="Image" /></td>
<td><img src="http://www.yorkshiresolar.com/pellet.html" alt="Image" /></td>
<td><img src="http://www.yougen.co.uk/renewable-energy/Solar-Thermal/" alt="Image" /></td>
</tr>
</tbody>
</table>

Besides different heating systems, there are also different **Heat distribution systems** available:

- Forced air
- Radiators
- Natural air flow
- Radiant floor or wall heating
- Individual room heating

### 5.4.2 Points of attention

Not every energy source is available everywhere. District heating is available in limited areas, and there are neighbourhoods without natural gas distribution system (often where district heating is supplied). This can limit the choice for a heating system.

Low temperature Heating systems need a larger heating surface area than high temperature heating systems, thus larger radiators. This is not always possible due to limited space in the rooms, and it can increase the costs of the renovation.

Buildings with a high thermal mass heat up and cool down slower than building with a low thermal mass.

### 5.5 Ventilation system

Ventilation is necessary in a dwelling to ensure a healthy indoor climate. With ventilation, moisture and harmful substances are removed from the indoor air, and fresh air is allowed to enter the dwelling. However, ventilation will result in unwanted heat losses, but energy efficient ventilation can reduce these heat losses.
5.5.1 Possible options

Ventilation systems can be based on four different principles: natural ventilation; natural inlet and mechanical exhaust, natural exhaust and mechanical inlet, or balanced ventilation. Mechanical ventilation systems use electricity for operating the fans in the inlets and/or outlets. However, modern ventilation systems use less electricity than older systems.

Balanced ventilation systems are mostly coupled with a heat recovery system, which heats the incoming air using the outgoing air. This decreases the heat losses through ventilation. A balanced ventilation system needs more ducts than mechanical exhaust ventilation, so this is not always possible. All ventilation systems need to be designed with a high enough capacity, installed in a correct way, and maintained regularly to avoid problems with noise, too low ventilation rates, pollution of the system or complaints of the tenants. Especially for balanced ventilation systems this is necessary, because these systems usually have no ventilation windows or grilles (only large opening windows), which hampers regular ventilation when the ventilation rate is too low.

Figure 10 type of ventilation systems (safe & care)

5.5.2 Points of attention

The most suitable ventilation system is dependent on the building characteristics. A new built dwelling with high airtightness needs a sufficient ventilation system to control the air quality in the building. This is in contrast with older buildings which low airtightness and therefore have a smaller need for a mechanical ventilation system, since the cracks and gaps provides a lot of natural ventilation.

5.6 Solar panels

Table 20 Most and least energy renovation measures - questionnaire results

<table>
<thead>
<tr>
<th>Most effective</th>
<th>Least effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Netherlands</td>
<td>The Netherlands</td>
</tr>
<tr>
<td>Solar panels and LED lighting</td>
<td></td>
</tr>
</tbody>
</table>

When the energy consumption is reduced as much as possible, there is still energy consumed by the tenants. Solar panels are a well-known measure to generate electricity in dwellings, if a suitable roof is available.
5.6.1 Possible options
There are several PV panel types on the market. The following PV panels are the most common:

- Monocrystalline (single-crystalline) silicon
- Polycrystalline silicon
- Thin film

Figure 11 types of PV panels (coastal climate control)

The monocrystalline has generally the highest efficiency, but it is also the most expensive. They also have the longest lifespan and usually have a warranty period of 25 years. At low light conditions they tend to produce more electricity than similar rated polycrystalline panels.

The polycrystalline solar cells are cheaper than the monocrystalline panels, but have a lower efficiency. They also have a slightly lower heat tolerance than monocrystalline panels, but the difference is minimal.

Thin film panels are cheap, but also less efficient. As dwellings have only a limited roof area, thin film panels are rarely used on dwellings.

5.6.2 Points of attention
Solar panels (photovoltaic or PV panels) currently have an average power of 160 Wp (Watt peak) per m². In the Netherlands, in optimal position (orientated to the south) PV panels can produce on average 150 kWh per m² annually. If the panels are focused on the east or west, the panel can still produce 125 kWh per m² on average. In south-European countries, the annual production of PV panels is higher. For example, in Spain, the average annual production of PV panels orientated to the south is 270 kWh per m². The average size of one panel is 1 by 1.65 meter, with a production power of 270 kWp.

When PV panels are partly covered with snow, dirt or shade, the efficiency of the whole circuit will decrease. This can be solved by using more than one inverter, but it is good to check the shading on the roof before installing solar panels.

Average prices of PV panels have dropped in the last years. In the Netherlands, average prices of PV panels are € 1.78 per kWp in 2016, including taxes and installation costs. The financial payback time is currently about 10 years; the energy payback time (the time it takes to generate the same amount of energy as being used in the production of the PV panels) is about 2.5 years. In other European countries, installation costs are similar.
5.6.3 Financing methods for PV panels
If social housing organisations do not have the means or if they are not willing to invest in solar panels, there are some alternative financing methods:

- "Zon op Nederland": this is a non-profit organisation that supports citizen solar energy initiatives. They offer the following solution: the social housing organisation makes the roof of their building available for the tenants to start their own solar energy initiative with the organisational help of "Zon op Nederland". The tenants then invest in the solar panels and are the owner of the solar panels.
- Social housing organisations can lease or rent solar panels.
- There are SHOs who are looking for large surfaces to install solar panels to generate electricity. Some of the social housing building blocks could be suitable for this. This provides the social housing organisations the opportunity to rent the roof tops of their dwelling to these organisations.

5.7 Energy performance contract

Table 21 Most and least energy renovation measures - questionnaire results

<table>
<thead>
<tr>
<th>Most effective</th>
<th>Least effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>France</td>
</tr>
<tr>
<td>- Energy performance contracts. A contract with the obligation to have a certain €/m3 heating costs and hot tap water costs etc. (FR)</td>
<td>- No responses</td>
</tr>
</tbody>
</table>

An energy performance contract is a contractual arrangement under which an energy service company designs and implements an energy renovation with a guaranteed level of energy performance. The payment for the services delivered is based (either fully or in part) on the achievement of energy efficiency improvements and on meeting the other agreed performance criteria (Salcedo Rahola, 2015).

The technical risks of the energy renovation measures are transferred from the client to the ESCO based on performance guarantees given by the ESCO. This will result in a lower risk for the social housing organisation, making it easier for them to invest in energy efficiency measures. For the construction company it will become in his interest to deliver a building that is more energy efficient than before.

5.7.1 Possible options
There are two options: guaranteed savings and shared savings.

Guaranteed savings: an ESCO (energy service company) guarantees a certain amount of energy saving (EC, 2015).

Shared savings: the cost savings are split for a pre-determined length of time in accordance with a pre-arranged percentage, the length of the contract and the risks taken by the ESCO and the consumer (EC, 2015).
5.7.2 Points of attention
To most important aspect in energy performance contracting is determining the baseline of the energy savings and the aimed energy savings. It is important to set a realistic but also ambitious energy saving goal in order to achieve the highest possible energy saving.

Additionally it is important to agree in advance on how the energy saving is determined (Milin et al., 2011b).
5.8 Energy renovation concepts

Building renovation concepts have been developed more and more in the building industry. This results in a more efficient building process, a higher quality, shorter project times, less waste and lower failure costs. There are several building renovation concepts on the market, such as:

- nul op de meter woning (Net Zero Energy dwellings)
- passive house
- nZEB (nearly Zero Energy Building)

Although the concepts are developed by different building contractors, the majority of them are based on the following principles:

1. insulate the building to an Rc-value ranging from 5.6 to 10
2. triple glazing
3. high airtightness
4. solar panels (on average 24-30 m² per dwelling)
5. often electrical heat pump (sometimes running on natural gas)
6. mechanical ventilation (in half of the cases with heat recovery)
7. energy performance warranty

Although some building concepts suggest that the dwelling will be energy neutral after renovation, this is not completely true. The aim of net zero energy dwellings concepts is to achieve a net energy consumption of zero. This means that the solar panels will probably generate more energy than needed during summer and too little energy during winter, but on average the dwelling will consume the same amount of energy as generated.
6 Barriers and solutions – summary of the workshop

Workshop TRIME “A closer look into renovation projects of Social housing associations”

Social housing associations aim to improve the energy efficiency of their housing stock, by adding more and improved insulation, installation of high energy efficient heating systems and production of renewable energy. This is accompanied with extra costs, but the benefits for the social housing associations are often low or none, in contrast with the profits for the tenants.

Additionally, a lack of technical knowledge and experience within the organisation, or organisational matters make it difficult to conduct energy renovations. However, a win-win situation is possible, where both the social housing association and the tenant benefit from the renovation.

Based on the findings of the previous chapters a workshop was organised. The interactive workshop with social housing organisations from Flanders and the Netherlands took place on 17th February in Breda, the Netherlands. During this workshop we took a closer look at energy renovation projects from a social housing organisations point of view and we aimed to answer to the question: What is a successful project and how can you make a project successful?

The workshop started with an inspiring presentation by Jan Verheyen from Zonnige Kempen (social housing association, Flanders) about the project Sint Antoniuspleintje. This project was set up as a demonstration project and contains extensive technological solutions. In his presentation Jan Verheyen reflected on the positive and negative experiences in this project. Because both, positive and negative experience are important to share.

In the second part of the workshop the participants shared the barriers they experienced when investing in energy efficiency measures and the measures they used to improve the energy efficiency of their building stock. Despite the diversity between the participating social housing associations, there were many corresponding barriers.

Some of the barriers and solutions that came up during the second part of the workshop were:

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The actual energy saving after renovation is often disappointing</td>
<td>- Combine maintenance work with</td>
</tr>
<tr>
<td>because of inefficient occupant behaviour</td>
<td>the implementation of energy</td>
</tr>
<tr>
<td>- Lack of financial means</td>
<td>saving measures. E.g. painting the</td>
</tr>
<tr>
<td>- Changing government policies</td>
<td>window frames and changing the</td>
</tr>
<tr>
<td>- Lack of knowledge which</td>
<td>glazing type</td>
</tr>
<tr>
<td>techniques result in the lowest</td>
<td>- work with performance contracting</td>
</tr>
<tr>
<td></td>
<td>- stay up to date with the available</td>
</tr>
<tr>
<td></td>
<td>subsidies to make projects feasible</td>
</tr>
</tbody>
</table>
Actual energy saving
- The labelling system does not reflect the reality.

Make use of BIM
- Special attention to tuning of building installations
- Special attention to explaining the occupant how to use their dwelling in the most optimal way.

In the final part of the workshop we focused on solutions overcoming the barriers. The participants indicated technical and behavioural barriers as the most important.

Based on the two most important barriers a brainstorm session in small groups was set up. The brainstorm session resulted in a large variety of possible solutions:

Solutions technical barriers:
- Upscaling, costs can be reduced when renovations are executed in larger scale.
- Thinking about the future. What are the most effective collective heating systems or individual heating systems? It is expected that more innovative systems will be introduced in future. A collective system is easier to adapt than individual systems. This could be a reason to use collective systems. However an individual system has a large impact on the overall 'happiness' of the tenants and stimulates the tenant to behave in a more energy efficient way.
- If technical renovations keep on showing disappointing results we should more focus on renewable energy instead of expensive high efficient heating devices.

Solutions occupant behaviour:
- Occupants should be approached by a person they trust (confidential)
- Don't bring energy efficiency measures only as a matter of saving money but highlight also the comfort gain he/she will experience.
- Create social interaction. E.g. keep one apartment empty and give the occupants the opportunity to rent it as an Airbnb. The money earned with this apartment can be used for energy efficiency measures in the building.
- Occupants with rent arrears have often more problems. Instead of sending all agencies separately there should be one person who contacts the resident. Energy efficient behaviour should be brought up as one of the solutions for rent arrear problem
- Combine maintenance work with energy efficiency explanations
- Make energy efficient and energy inefficient behaviour visible e.g. with a demonstration dwelling.
- Involve local schools, restaurants and pubs in energy awareness campaigns
- Merge the individual housing contract signing appointments to one collective moment once per month. A part of this session can be devoted to energy efficient behaviour.

Overall it can be stated that this was a fruitful workshop that provided the TRIME team with new insights in possible solutions for energy efficient implementation of energy saving measures.

More information about the workshop (program, invitation, location etc.) can be found in the report “D3.4 Report Co-creation workshop”.
7 Conclusion

Based on the findings of the literature study, questionnaire, interviews and the workshop among Social housing organisations in Belgium, France, Spain, the Netherlands and United Kingdom we can conclude that all social housing organisations experience barriers toward energy renovations but they are all motivated to overcome these barriers to improve the performance of their dwellings. This conclusion provides an overview of the most recognised barriers by the respondents of the questionnaire and the solutions that are identified by the respondents to be efficient. It should be taken into account that the results of the questionnaire are only based on the opinion of 27 social housing organisations, which is not a representative number; nevertheless these results give an indication of the most important barriers and most effective solutions.
Table 23 Top 10 barriers for social housing organisations to invest in energy efficient measures. Based on questionnaire results

<table>
<thead>
<tr>
<th>Top 10 barriers based on questionnaire results</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Lack of funds (Atanasiu et al., 2011) <strong>financial</strong></td>
</tr>
<tr>
<td>10. The most ambitious retrofits will require more funding upfront compared to the common retrofits. With a tight budget it’s likely that corporations will compromise on spending on energy efficient measures. (Atanasiu et al., 2011) <strong>financial</strong></td>
</tr>
<tr>
<td>11. Consultants and designers should be involved early in the process (Donkelaar et al., 2006, Häkkinen and Belloni, 2011) <strong>organisational</strong></td>
</tr>
<tr>
<td>12. The social housing organisation makes the investment but does not gain the benefits from the investment. This problem is known as: ‘split incentive barrier’, ‘landlord/tenant barrier’, ‘investor/user barrier’, or ‘principal/agent barrier’. (Atanasiu et al., 2011, Cadima, 2009) <strong>financial</strong></td>
</tr>
<tr>
<td>13. Technical limitations of existing building stock (Atanasiu et al., 2011); <strong>technical</strong></td>
</tr>
<tr>
<td>14. Renovation could be combined with upgrading the neighbourhood; (Donkelaar et al., 2006) <strong>organisational</strong></td>
</tr>
<tr>
<td>15. Competing purchase decisions, investments in energy efficiency are not always considered the most important/popular investment for a social housing organisation; (Atanasiu et al., 2011) <strong>financial</strong></td>
</tr>
<tr>
<td>16. The energy efficiency measures are not reflected in the market price of the building, while the measures taken are often not visible (Meijer et al., 2009, Atanasiu et al., 2011). <strong>financial</strong></td>
</tr>
<tr>
<td>17. Planning authorities pose often restrictions towards the retrofit of heritage buildings. Only a limited amount of retrofit measures are suited for these types of buildings (Atanasiu et al., 2011). <strong>technical</strong></td>
</tr>
<tr>
<td>18. The contractor is not always familiar with the most recent energy efficient solutions due to the high pace of the solutions are developed. (Atanasiu et al., 2011) <strong>technical</strong></td>
</tr>
</tbody>
</table>

Table 24 Top 11 solutions for social housing organisations to invest in energy efficient measures - based on questionnaire results

<table>
<thead>
<tr>
<th>Organisational solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tenants are expected to be more open towards renovation when the increased comfort</td>
</tr>
</tbody>
</table>
as a result of renovation is clear for them; (Meijer et al., 2009, Atanasiu et al., 2011, Donkelaar et al., 2006) **organisational**

2. Combine regular maintenance with implementation of energy saving measure. (Donkelaar et al., 2006) **technical**

3. Consultants and designers should be involved early in the process (Donkelaar et al., 2006, Häkkinen and Belloni, 2011) **organisational**

4. Conventional financing: tenants will be completely/partly charged for the investment by means of rent increase. (Donkelaar et al., 2006) **financial**

5. Gather the experience from previous projects and document those structurally. These can be used as a reference guide (Donkelaar et al., 2006) **technical**

6. Renovation could be combined with upgrading the neighbourhood; (Donkelaar et al., 2006) **organisational**

7. Introduction of the building energy rating should result in more awareness under the tenants (Atanasiu et al., 2011, Itard et al., 2008); **organisational**

8. Offer educational programs for professionals to keep them up to date (Atanasiu et al., 2011) **technical**

9. Living Expenses Guarantee: Housing association gives tenants a guarantee that the total living expenses (consisting of the rent and secondary expenses like energy costs, cable and telephone) during a certain period of time will not increase more than a common inflation rate. This removes the rent increase barriers for tenants. (Donkelaar et al., 2006) **financial**

10. Education programs could make the social housing organisations more aware of the importance of energy efficiency (Itard et al., 2008, Meijer et al., 2009) **organisational**

11. Projects that are well documented should be distributed under the experts and social housing organisations in order to stimulate the execution of future projects (Tommerup and Svendsen, 2006, Donkelaar et al., 2006) **organisational**

Apart from these ‘standard solutions’ during the **interviews** the following solutions were mentioned to be effective:
### Table 25 solutions from interviews

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>If a housing organisation has a large amount of similar dwelling types the solution can be to optimize the renovation approach for this type of dwellings.</td>
</tr>
</tbody>
</table>
| 2. | If the budget is reducing the possibility to renovate the social housing organisation should search for other financing solutions. For example:  
   a. Reserve a budget for energy renovations in the start of the year; |
| 3. | Renovate after mutation to avoid problems with occupants; |
| 4. | Combine the renovation of pressing technical measures (e.g. foundation problems) with energy renovation measures. |
| 5. | If the opportunity comes by try to bring the dwellings on the highest possible level. Don't waste your chances |
| 6. | Increase rent after renovation (not in every country allowed or desired); |
| 7. | Attending European and national projects focussing on innovative energy renovation measures can help social housing organisations to find new and sometimes better solutions for energy renovations. |
| 8. | Keep in mind that you have to invest in order to learn; |
| 9. | Check if it is more efficient to demolish instead of renovate; |
| 10. | Follow the newest renovation narrowly e.g. hire a sustainability employer who keeps track of all new sustainability innovations (e.g. follow the development of hydrogen boilers for dwellings); |
| 11. | Energy efficiency measures do not only cost money. For example: Multifamily dwellings that are highly insulated and are airtight require less energy for heating, therefore it is a possibility to use an condensing gas boiler, that is normally used as an individual system, as a central heating system. Two boilers can heat 8 houses instead of one, which means that housing organisation only needs to purchase two boilers instead of 8 and also has to maintain only two boilers. |
| 12. | Focus not only on short term solutions but also/primarily on long term solutions |
| 13. | Try to keep your knowledge up to date although the market is changing rapidly |
| 14. | The airtightness of a building is important to reduce energy consumption for heating, always a test after the construction took place to determine if the required airtightness is reached; |
| 15. | Energy performance contracting can help to stimulate the contractor to deliver the energy savings he promised. |
| 16. | Make a standard template for energy renovation measures per dwelling type, but always hire an expert to tailor the advice for the specific dwelling; |
| 17. | Install the same brand as much as possible to keep the maintenance work clear; |
| 18. | Make a clear business case that shows that energy efficiency is not only a nice thing to do but also has a positive impact on your business incentive; |
19. Not only apply the commonly known installations but also try alternatives.

During the workshop new solutions were made up. These solutions are not (yet) always tested in practice. Solutions from social housing organisations

**Table 26 solutions for technical barriers - workshop results**

**Solutions technical barriers – workshop results:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Up scaling, costs can be reduced when renovations are executed in larger scale.</td>
</tr>
<tr>
<td>2.</td>
<td>Thinking about the future. What are the most effective collective heating systems or individual heating systems? The expectation is that the coming years more innovative systems will be introduced. A collective system is easier to adapt than individual systems. This could be a reason to use collective systems. However an individual system has a large impact on the overall 'happiness' of the tenants and stimulates the tenant to behave in a more energy efficient way.</td>
</tr>
<tr>
<td>3.</td>
<td>If technical renovations keep on showing disappointing results we should focus more on renewable energy instead of expensive high efficient heating devices.</td>
</tr>
</tbody>
</table>

**Table 27 solutions occupant barriers - workshop results**

**Solutions taking the occupant into account – workshop results:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Occupants should be approached by a person they trust (confidential)</td>
</tr>
<tr>
<td>2.</td>
<td>Don’t bring energy efficiency measures only as a matter of saving money but highlight also the comfort gain he/she will experience.</td>
</tr>
<tr>
<td>3.</td>
<td>Create social interaction. E.g. keep one apartment empty and give the occupants the opportunity to rent it as an Airbnb. The money earned with this apartment can be used for energy efficiency measures in the building.</td>
</tr>
<tr>
<td>4.</td>
<td>Occupants with rent arrears have often more problems. Instead of sending all agencies separately there should be one person who contacts the resident. Energy efficient behaviour should be brought up as one of the solutions for rent arrear problem.</td>
</tr>
<tr>
<td>5.</td>
<td>Combine maintenance work with energy efficiency explanations</td>
</tr>
<tr>
<td>6.</td>
<td>Make energy efficient and energy inefficient behaviour visible e.g. with a demonstration dwelling.</td>
</tr>
<tr>
<td>7.</td>
<td>Involve local schools, restaurants and pubs in energy awareness campaigns</td>
</tr>
<tr>
<td>8.</td>
<td>Merge the individual housing contract signing appointments to one collective</td>
</tr>
</tbody>
</table>
moment once per month. A part of this session can be devoted to energy efficient behaviour.

Furthermore, best practices for energy renovations for the following building parts and financing solutions were described:

- Glazing (section 5.2)
- Insulation (section 5.3)
- Heating systems (section 5.4)
- Ventilation systems (section 5.5)
- Solar panels (section 5.6)
- Energy performance contracts (section 5.7)
8 References


SALCEDO RAHOLA, T. B. 2015. Integrated project delivery methods for energy renovation of social housing. PhD, Delft University of Technology.


SOZER, H. 2010. Improving energy efficiency through the design of the building envelope. Building and Environment, 45, 2581-2593.


THE PARTNERS

The TRIME project team includes the following organisations: