Obligations in the existing housing stock: Who pays the bill?

Casper Tigchelaar
ECN Policy Studies
P.O. Box 1
1755 ZG, Petten
The Netherlands
tigchelaar@ecn.nl

Marijke Menkveld
ECN Policy Studies
P.O. Box 1
1755 ZG, Petten
The Netherlands
menkveld@ecn.nl

Bert Daniëls
ECN Policy Studies
P.O. Box 1
1755 ZG, Petten
The Netherlands
daniels@ecn.nl

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Abstract

The huge saving potential in the existing housing stock is very important for reaching energy efficiency goals. Providing information (energy performance certificates) doesn't seem to be sufficient to make households invest in energy saving measures. Both on a national and on a European level, policy makers are making the shift towards more mandatory measures. Countries such as the UK and France have energy efficiency obligations for energy suppliers (white certificates) and in the EPBD recast mandatory standards are being introduced.

This paper draws on analyses done for the Dutch government. We have evaluated several options for mandatory policy measures, including white certificates, obligations based on energy performance certificates and minimum standards for building components. For a sample of over 4,700 households, representative for the Dutch housing stock, we combined empirical data about their energy consumption, the technical state of their houses and their income. A vast number of combinations of saving measures have been calculated (over 60 per dwelling on average) to evaluate the saving potential and required investment costs per dwelling.

With this detailed information we were able to estimate the effect that policy measures have on individual households, what investment costs they have to make to comply with obligations and how much they save on their energy bill. Analysing this sample allows us to draw conclusions about those who benefit and those who have to pay the bill if a policy measure is implemented. We conclude that heating behaviour is a key factor for cost-effectiveness and in this paper we will discuss how this affects the outcome of different types of policy measures and the effect they have on (groups of) individual households.

Introduction

Both on a European and national level the large energy saving potential in the built environment is considered important for realising the targets in energy policy.

To actually stimulate owners of dwellings to take efficiency measures often turns out to be difficult. Mandatory policy instruments are increasingly considered to be a real option to realise the potential. For example, in the recast EPBD directive the requirements for existing buildings were expanded to include smaller buildings such as dwellings in the obligation to take cost-optimal measures in large-scale renovations.

To enforce such obligations on individual homeowners and landlords in a responsible manner, their impact must be studied, for example on the living expenses of households. Average values are assumed too often. In this article the large variety in households is shown, as well as the fact that this needs to be taken into account when assessing and designing policy instruments. We will show that heating behaviour is a key factor for cost-effectiveness. As a consequence, mandatory standards that are based solely on technical properties of houses will have negative financial effects on many households. We discuss different kinds of obligations and their effect on household expenditures. We also show that the Dutch changes in rental legislation have a positive effect on the split incentive problem when landlords are investing in energy saving measures

First we address the used methodology. Subsequently we describe the variation among households and the cost effectiveness of technical energy efficiency measures, as well as the fact that heating behaviour in households is an important element for the cost effectiveness. Finally, we discuss the consequences for the effects of mandatory policy measures.

METHODOLOGY USED

For this study we developed a model to analyse the variation among households. The model consists of different elements described below.

Random sample survey households

The first element is a database that contains detailed information of over 4,700 Dutch households. The data of these households were obtained through a large survey among households, conducted by the Dutch Ministry of Housing, Spatial Planning and the Environment. This so-called WoON 2006 survey contains information about family characteristics such as number of family members, income, paid taxes, energy use, et cetera.[1] It also contains information about people's wishes with regard to their living situation. At the same time auditors drawn up an energy performance certificate for each respondent's home and they gathered detailed technical data of the dwelling. Each respondent was coupled with a weighting factor to enable the data set to provide a representative image of the Dutch housing stock and division of households. This makes it a very detailed representative indication of the Dutch housing stock for the year 2006.

Packages of energy efficiency measures

The second element is an overview of possible packages of technical energy efficiency measures. The Dutch Ministry of Housing, Spatial Planning and the Environment commissioned engineering agency DGMR to map which energy saving measures are suitable for each of the more than 4,700 respondents and how this would translate in terms of energy saving.[2] Not only the effects of individual measures were calculated; all combinations of measures, so-called packages of measures, were also examined. A total of on average 60 different packages were calculated for each respondent. This way a detailed overview was made of which technical measures would be feasible as well as the saving potential of the Dutch housing stock.

Calculating costs and benefits

The third element consists of a calculation module designed by the Energy research Centre of the Netherlands (ECN). This module calculates the costs and benefits of the saving packages and subsequently selects the most attractive saving package. Each saving package contains information about square metres, flooring, facade and window insulation and heating system. The calculation module uses cost indicators[3] to calculate the total investment costs per package and is able to include subsidies or other financial benefits in the calculation. The investment costs are translated into financial burden. The results presented in this article are based on a depreciation period of 20 years and a mortgage loan with 5 % interest for owner-occupiers. The Dutch fiscal system of mortgage interest relief has also been taken into account in detail. It allows owner-occupiers to deduct the paid interest from the income tax, resulting in an average interest benefit of 42 %. In the case of social landlords/housing associations an interest rate of 3.5 % is assumed, because they can get loans under more favourable conditions due to government guarantees. Private landlords pay an interest rate of 5 % and are not allowed to use mortgage interest relief. Investment costs for landlords can be passed on to the rent under certain conditions. As for the tenants' burden, government regulation, which establishes the maximum allowed rent, has been taken into account. The system of rent benefit has also been taken into account, which offers financial support to tenants with low incomes.

For each saving package a calculation was made of the amount of energy that is saved; the financial benefits are calculated by multiplying the saved energy with the energy prices. The detailed information about investment burden, rent increase and lowered energy burden was used to calculate the effect of each package on the annual living expenses per household. If the annual benefits are higher than the annual (capital) costs, the investment is considered to be cost-effective. Moreover, the payback times of the various packages were determined, since this is another regular way to present the cost-effectiveness of technical measures. Payback times are calculated by dividing investment costs by yearly benefits from energy savings.

Selecting the most appealing saving packages

The costs and benefits of each saving package are known, thus enabling identification of the (financially) most appealing saving options for each individual household. Some packages may be excluded by policy, for example due to requirements related to payback time, component requirements or policy that is linked to energy performance certificates. Within these existing boundary conditions, a number of packages were selected that have the most favourable effect on the total living expenses of a household.

Output

The model yields micro level output per respondent or group of respondents as well as output on the national macro level by applying weighting factors. The model results include the following:

- Realised energy saving and remaining energy use after saving.
- Necessary investments.
- Annual change in burden due to policy measures for end users, government and landlords.
- Annual change in burden broken down according to income groups.
- Variation in burden change among households.
- Change in label distribution.

1. Ministry of Housing Spatial planning and the Environment (2007), Wonen op een rijtje, De resultaten van het Woononderzoek Nederland 2006, VROM Den Haag

2. DGMR (2006), De Nederlandse woningvoorraad en het energielabel, verantwoording bij de verrijking van de KWR met energiecertificaatgegevens en de koppeling met de SenterNovem variantentool, DGMR Maastricht

3. PRC kostenmanagemen (2010), Actualisatie investeringskosten Maatregelen epa-maatwerkadvies Bestaande woningbouw 2010

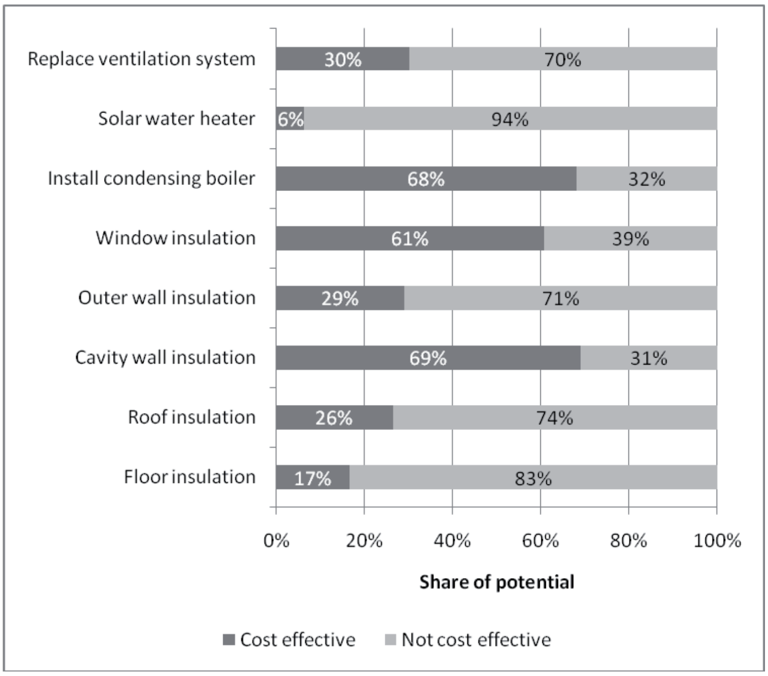

Figure 1: Percentage of the number of households where saving measures can be taken, either or not in a cost-effective manner.

The above-mentioned information is available for home-owners, social landlords/tenants, and private landlords/tenants. Investments are more cost-effective when a technical measure was due to be replaced, because of regular maintenance. In our calculations we took these differences into account.

Four types of policy measures have been evaluated, with in total 60 different levels of stringency.

Analysis

The model calculations have resulted in a large quantity of data, which has been used to map the variation among households and to seek explanatory factors. The next paragraph will address the results.

Results show variety in cost effectiveness

The model calculations show that there is a large variety among households with respect to the cost effectiveness of taking energy efficiency measures. As an indication for the cost effectiveness, Figure 1 shows a list of possible energy saving measures. A percentage is provided for each measure, indicating the number of households where this measure can be applied in a cost effective manner. What is striking is that none of the measures are cost effective at all times. Installing a high efficiency boiler and cavity wall insulation are considered very profitable measures by Dutch households. However, the analysis shows that in more than 30 % of the cases such measures do not lead to lower living expenses for the occupants. Solar boilers, on the other hand, are usually considered expensive but can be installed in a cost-effective manner for 6 % of the households.

For reasons of clarity we presented individual measures in Figure 1. In our study we didn't solely looked at individual measures but also at combinations, which makes it possible to combine profitable with non-profitable measures. Even then the cost-effectiveness of packages differs per household.

Based on these results we can draw the conclusion that we cannot use national averages to determine which measures will be cost-effective and which ones not. Particular household related differences render a measure appealing for one household but not for another one.

HEAT DEMAND OF HOUSEHOLDS IS MAIN FACTOR FOR LIMITED COST EFFECTIVENESS

We've looked for factors that can explain the large differences in cost effectiveness of the packages of measures. We've conducted targeted research to identify specific characteristics of households or dwellings that could cause the observed differences.

There turned out to be no strong link between the cost effectiveness of the saving packages and the dwelling type to which they are applied. The construction year of the house does not provide a good explanatory factor either. From the analysis it became clear that the main factor that determines the cost-effectiveness is the heating behaviour of households.

The energy use of households is determined by its heat demand, which in turn is determined by the number of heating hours, the desired indoor temperature and the amount of hot water that is used. Saving measures can help reduce this heat demand by reducing heat loss (insulation) or by addressing the demand in a most efficient manner (high efficiency boiler). However, the saving depends on the original heat demand as it was before the measures were taken. If more heating takes place and more showers are taken, this will result in a higher heat demand and hence also a higher saving. Similarly, if less heating takes place and fewer showers are taken, this will imply a lower heat demand and hence a lower saving. The investments for certain saving packages are the same in both cases, but the saved energy costs are much lower in the case of lower energy demand. The cost effectiveness in case of lower heat demand is therefore also much lower. In theory, the heat demand has

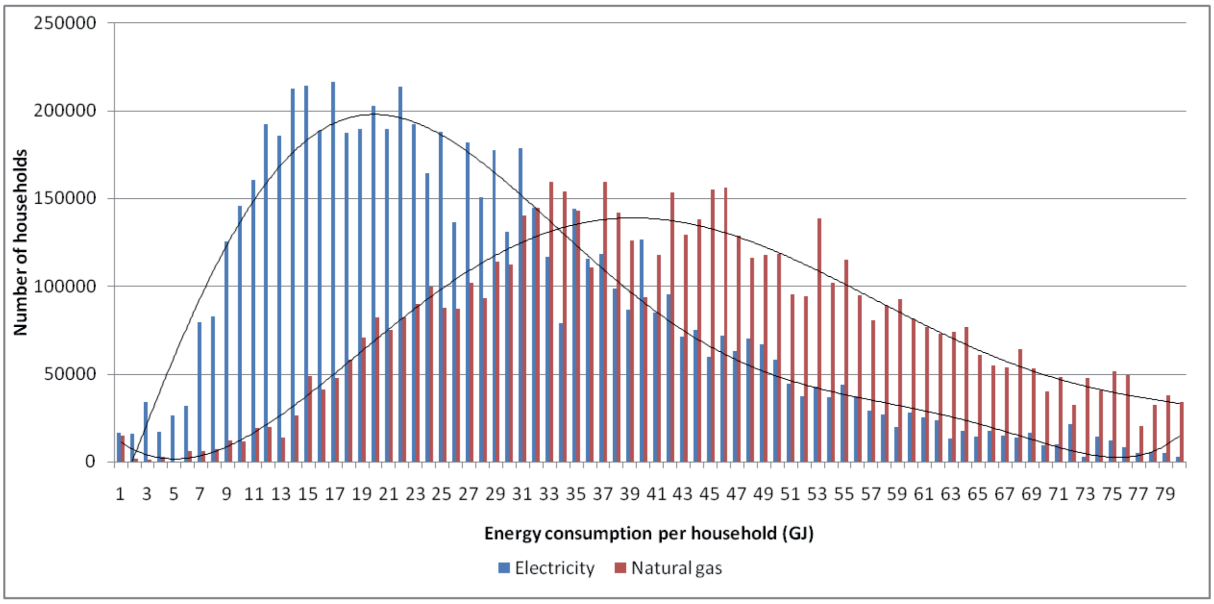

Figure 2: The distribution of energy use per household, broken down into gas and electricity use, for all Dutch households.

much influence on the cost effectiveness. For policy purposes it is therefore important to map the existence of large differences in heat demand among households and to find an explanation for these differences.

DETERMINING RELATIVE HEAT DEMAND OF HOUSEHOLDS

The energy use of each of the respondents in the random sample survey is known from databases of energy companies. These are the actual meter readings and therefore reliable data about actual use. Figure 2 shows the large variety in energy use among households. The graph only includes natural gas consumption for heating, since this is by far the most used heating fuel in households in the Netherlands.

Two factors influence this variation.

- Technical characteristics of the dwelling such as type, size and degree of insulation.
- The heat demand resulting from the occupants' behaviour. This depends on the length of presence in the dwelling, but also on heating behaviour such as temperature adjustment and the number of heated rooms.

The technical characteristics of the dwelling have been mapped effectively with the Energy Performance Certificates that have been implemented in the Netherlands in 2008 in the framework of the EPBD directive. Each certificate is based on an extensive calculation, in which detailed technical characteristics are used to determine a theoretical energy use per m^2, based on standard heating behaviour.[4] This theoretical energy use can be compared to the actual energy use for the data set. If we assume the theoretical calculation to be plausible, then the difference between both uses must be caused by the occupants' behaviour. If we divide actual use by theoretical use, a score is calculated that can be used to indicate the heating behaviour of a household. That score will be referred to as the heating factor in this paper. A heating factor of 1 means that the energy demand exactly matches the theoretically expected energy demand. A heating factor below 1 implies a lower demand than expected and a heating factor higher than 1 means that demand is higher than expected. In the data set the scores vary from little over 0.25 to 1.75, indicating a wide range.

Figure 3 contains an example of how the payback time of low-E glazing depends on the heating factor which indicates the relation between the theoretical and actual energy use. The X axis shows the heating factor and the Y axis reflects the payback time. Each dot in the graph represents a household from the data set. The figure shows clearly that installing insulation glazing is less rewarding for households with a relatively low heating factor than for households with a high heating factor. Households that have a score of over 1 should usually be able to recover the cost within 10 years. On the other hand, there are households that have a relatively low use which are not even able to recover the entire investment cost within the technical lifetime of the glazing. Such a relation has not only been found for glass insulation, but for all saving measures and thus for all packages of measures as well.

The analysis clearly shows that heat demand in particular determines the cost-effectiveness of saving measures. A larger heat demand implies larger savings and shorter payback times. Not only the technical characteristics of a dwelling result in higher heat demand; the same is true for occupant's behaviour. Corrected for technical characteristics of the dwelling, the heat demand varies strongly among households.

RELATION TECHNICAL CHARACTERISTICS AND RELATIVE HEAT DEMAND

We have established that the non technical differences in heat demand among households are large. Another striking result from the study is the fact that there is a correlation between the technical characteristics of a dwelling and the non technical variation among households. It looks as though occupants in an energetically efficient dwelling demonstrate more energy

4. Elaborate information about the calculation can be found in ISSO (2008), Publicatie 82.3 Handleiding EPA-W "Formulestructuur", ISSO, Rotterdam

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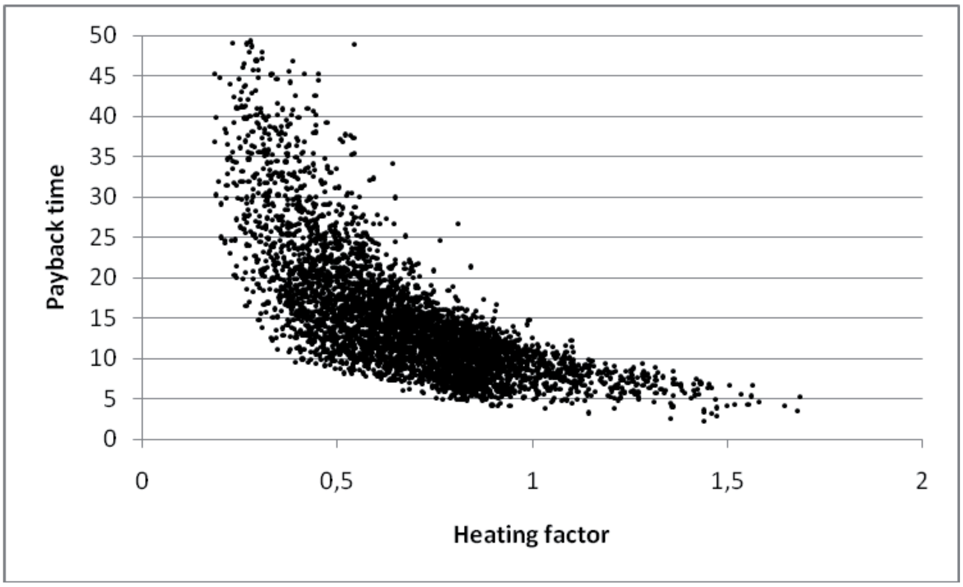

Figure 3: Relation heating behaviour (expressed as relation between actual and theoretical use) and payback time for installing low-E glazing.

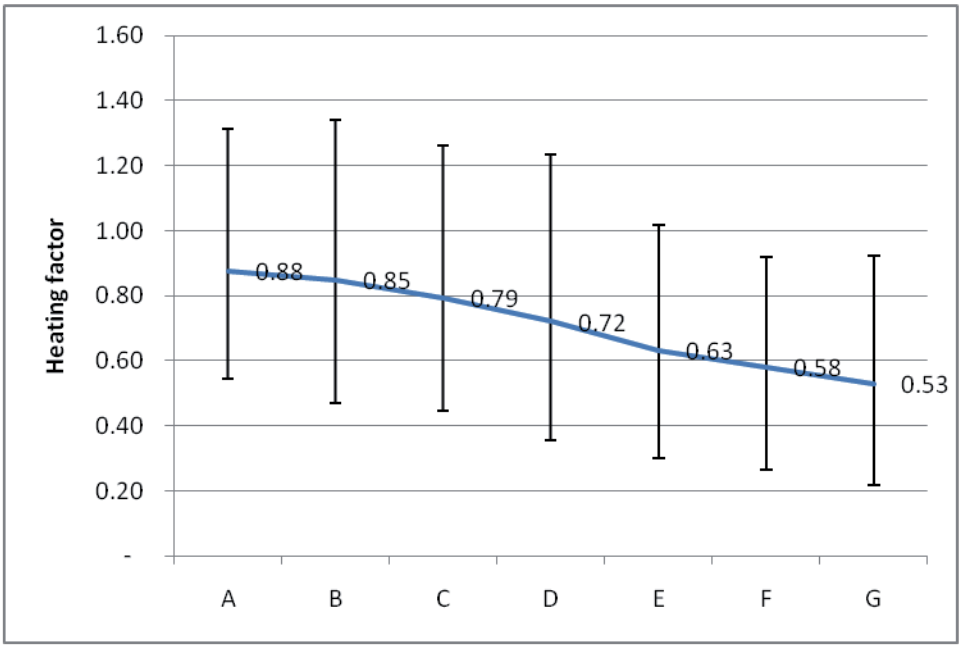

Figure 4: Relation between the energetic quality of a dwelling expressed in label score and the heating factor (expressed in relation actual and theoretical use). The heating factor varies also among households with the same label. 95 % of the households have heating factors within the limits illustrated with the bars).

intensive behaviour compared to occupants in energetically poor quality dwellings.

This striking relation has been indicated in Figure 4. The energetic quality of the dwelling in this figure is expressed by the same letters as used on an energy performance certificate in the Netherlands. An 'A' represents an efficient dwelling and a 'G' refers to an inefficient dwelling. Once again the heating behaviour is expressed as heating factor, which is based on the relation between theoretical and actual use. In an average dwelling with label A the heating behaviour is 27 % more intense than in the average Dutch dwelling. In an average G labelled dwelling the heating behaviour is 23 % less intensive than in the average Dutch dwelling. This connection has been proven by this study, but the cause for this connection has not been studied. One possible explanation is that similar households show less efficient behaviour if the dwelling itself is more efficient, but it could also be that dwellings with a label G attract different kinds of households than dwellings with a better label. Additional research is needed to obtain better insight.

Energetically good quality dwellings use less energy, but this effect is partly compensated by more intensive heating behaviour. On the other hand, poorer quality dwellings use more energy, but this is limited by less intensive heating behaviour. This effect is so strong that even in the energetically poorest quality dwellings with a G label it is often impossible to take cost effective measures. Based on the above, we cannot simply conclude that the occupants show more intensive heating behaviour because of the saving measures. Other possible explanations include incorrect assumptions in the theoretical calculation or the fact that some labels are more often present in specific types of dwelling in which different types of households live. Further research needs to be done before any conclusions can be drawn here.

The data also shows that the average heating factor in our sample is below 1. This indicates that the theoretically estimated heat demand is overestimated. Additional research is needed to explain these differences. Since we only used relative anomalies for our study this doesn't affect our conclusions. We did checks with corrected figures to confirm this.

All in all, the fact that occupants' behaviour is important for the cost effectiveness has become clear. Policy makers will also need to take these non technical factors into account when formulating energy saving policy. Energy labels only provide information on the technical aspects of the dwelling. This is not sufficient to identify favourable potential. The fact that this has consequences for the effectiveness of policy instruments will be addressed in the next section, in which various options for mandatory policy are discussed.

Effect of mandatory policy on living expenses

What consequences for policy instruments arise from the variety among households? The previous sections address the issue that investing in energy saving is not cost-effective for a significant part of the households. If the government imposes obligations, this means that this group will be forced to take measures that are unprofitable.

The effects of various different policy instruments have been examined for the Dutch government. This paper addresses the component standards, label standards, payback time standards and white certificates. We will also discuss split incentives for the rental sector and the solution provided by the Dutch government.

COMPONENT REQUIREMENTS

As described above, technical saving measures are not profitable for all households. If the government imposes energy saving standards with regard to components such as roofs, facades or installations, this means that some households will be forced to take measures that are unprofitable. Table 1 illustrates the volume of the saving potential of a particular measure in Dutch dwellings. It also indicates the percentage of cases in which a household cannot take the measure cost-effectively and how much spending power they annually lose on average. It provides a picture of the consequences for households if component standards are enforced by the government.

Consequences of the recast EPBD

In the recast of the Energy Performance of Buildings Directive (EPBD) which was adopted in may 2010, it is stated that countries must enforce requirements on existing dwellings at times of renovation. In the directive, it is stated that dwelling owners must be obliged to take cost-optimal measures in major renovations. The directive uses lifecycle costs as a guideline for cost-optimality. This means that costs are spread over 30 years sometimes. Although there's an economic rationale behind this choice, it doesn't match the way households think about cost-effectiveness. It is not likely that a household will base its investment decisions on a period of 30 years. The EPBD recast will enforce mandatory measures that don't appear to be cost effective for homeowners.

Apart from the opinion of households, the actual cost-effectiveness of measures is very difficult to determine for governments. Enforcers of these obligations are likely to use theoretical values that are based on average dwellings. The wide variety among dwellings and especially in heating behaviour as described in this paper are thus disregarded. As a consequence, many households, homeowners and tenants, with a relatively low energy use are forced to take unprofitable measures.

This problem could partly be overcome if the heating factor described above, is used as an additional criteria for mandatory improvements at times over renovations. Households that can prove with an EPC and their energy bill that their energy consumption is far less than theoretically expected, could be relieved from this obligation.

OBLIGATIONS BASED ON LABELS

Another option to enforce energy saving in existing dwellings is to base the obligation on the Energy performance certificates. A household can thus be forced to improve their dwelling if it does not meet the established minimal label requirement. The effects of such a requirement have been studied for the Dutch ministries. To this end mandatory label steps and phase-out of certain labels were examined. For example, if C label dwellings or lower are phased out, this implies that as of a certain date all dwelling at least need to comply with the quality requirements of a B label.

Figure 5 reflects that such an obligation can have large saving effects. The total gas use in households is about 312 PJ. This could be improved by mandatory improvement of all dwellings with label C or worse, leading to a 156 PJ reduction.

As mentioned before, there are even some dwellings with a G label and hence poor energetic quality, which do not qualify for taking cost effective measures. This means that for these households not one of the packages of measures calculated results in lower annual costs. This is mainly because such a household heats less intensively and fewer savings can be made with regard to the energy costs. In Figure 6 the cost curves reflect which percentage of the involved households will benefit or experience drawbacks and to what extent if they are forced to make investments. This involves changes in the annual living expenses, taking into account the financing costs of the investments, the energy saving and any changes in rent and changes in taxes. If all occupants of dwellings with a label B or lower are forced to take measures to improve the dwelling to label A level, 60 to 70 % of this group will be worse off. In the phase out of dwellings with label G this still amounts to 10 to 20 % of the households.

PAYBACK TIME REQUIREMENTS

Theoretically, it is possible to impose requirements on owners of dwellings based on payback times of packages of measures. This is one way to prevent households from being forced to take unprofitable measures. Calculations have been made to deter-

Table 1: Saving potential of technical measures, share of not cost effective potential and average additional costs for these households.

	Saving potential (PJ)	Share of not cost effective potential (%)	Average additional yearly expenditures (min - max)
Floor insulation	18	83%	131 (2 - 1022)
Roof insulation	26	74%	156 (0 - 1590)
Cavity wall insulation	28	31%	27 (1 - 100)
Outer wall insulation	27	71%	250 (0 - 3094)
Window insulation	39	39%	31 (0 - 338)
Replace heating system	41	32%	43 (0 - 136)
Replace ventilation system	15	70%	122 (0 - 284)

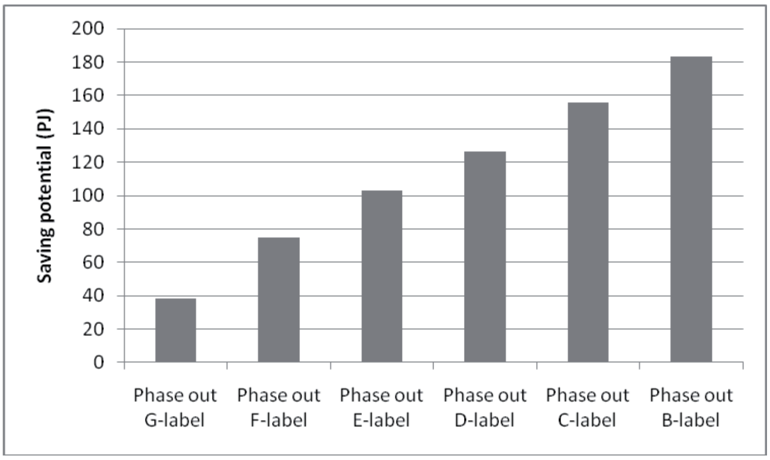

Figure 5: Dutch national energy saving in dwellings in case of phase out of labels. The total gas use in Dutch dwellings is 312 PJ.

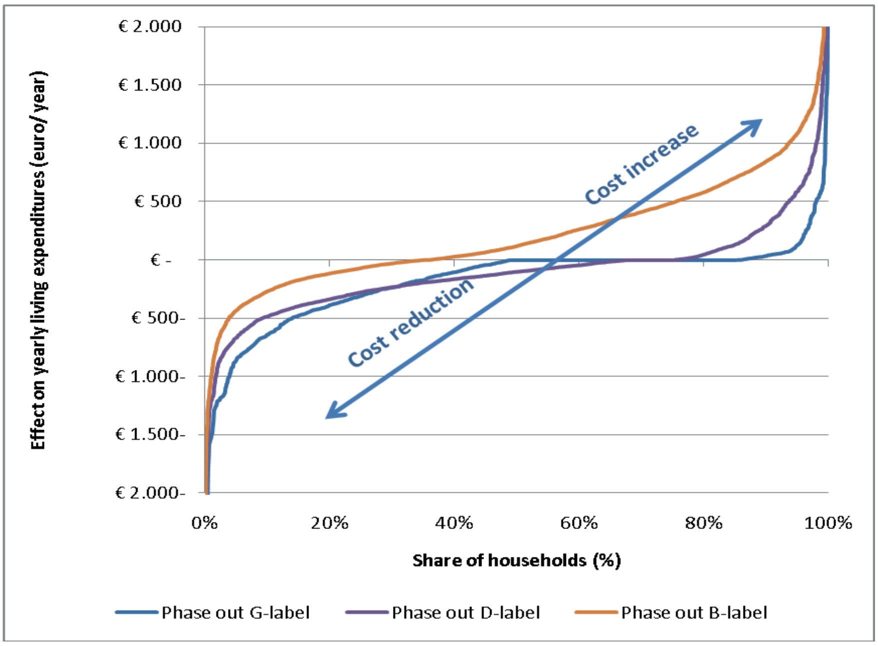

Figure 6: The effect on the living expenses of households in case of phase out of dwellings labelled B, D or G.

mine the saving potential in the existing Dutch housing stock in case of a payback time of respectively 5 and 10 years. In case of a payback time of 5 years 26 PJ can be saved. In the case of a payback time of 10 years this amounts to 81 PJ.

The main problem of such an obligation is the availability of information for the enforcer. There is no fully complete information available about the technical situation of the Dutch housing stock and hence no fully complete information about the potential measures that can be taken in each individual dwelling. Not to mention information about which households can take measures that will have a payback time of 5 or 10 years. This makes it difficult to oblige individual households to take cost effective measures. If the obligation only applies in case of renovation, the potential could be examined when issuing the construction permit. Because permits for renovations are provided for merely several tens of thousands of dwellings every year, only a limited number of households will be reached this way. In case of relocation, the issuing of an Energy Performance Certificate could be used to map where cost effective measures can be taken. The relocations involve about 6 % of the housing stock annually, hence the full potential will only be realised in the long term.

More importantly, the government is theoretically able to map which technical measures have a shorter payback time, but as we have already seen this does not mean that it is cost effective in practise. As mentioned before, the heating behaviour of households is a crucial factor for cost effectiveness. Whether or not a dwelling can be improved in a cost effective manner thus differs greatly from one household to the next and as a result it is impossible to implement general government policy.

WHITE CERTIFICATES

A more targeted approach of households can be realised by means of a white certificate system, in which energy suppliers are obliged to save energy in dwellings. Such a system consists of a single target for an energy supplier to realise a saving of X PJ before a certain date. A fine will be imposed if this target is not realised. This will require energy companies to install energy saving measures in dwellings, for which they will receive white certificates that can be used to show that the company has met its obligation. A company cannot install measures by itself, but will have to collaborate with homeowners. These will only collaborate if they receive an appealing offer, for example through a premium from the company. The larger the imposed target, the higher the need for homeowners to collaborate and the higher the premium that is needed to persuade sufficient households.

Such a system has already been introduced in various countries in Europe. The main advantage is that the energy company can seek dwellings in which they can take the most cost effective measures. Households that are unable to take cost effective measures due to low energy use are allowed to refuse and are not forced to take unprofitable measures.

Model calculations show that costs for energy companies may rise significantly as the targets become more ambitious. Contrary to label obligations, white certificates allow each household freedom of choice to take measures. Once an investment leads to larger costs savings, households will become more willing to take that measure. But the exact relation is unclear. In the model an assumption was therefore made as to the relation between cost effectiveness of a saving package and the willingness of a household to deploy that package. For each household in the data set, the model determines how cost effective certain investments are as well as the chance of a household taking this measure. The participation of households can be influenced by energy suppliers if they subsidise part of the costs, resulting in participation of more households. As the targets imposed on the energy companies become higher, they will have to take on a larger part of the investment cost in order to realise sufficient savings.

Figure 7 shows the relation between a saving target for energy companies enforced by the government and the total investment costs needed to realise it. The figure also shows how many billions of euros need to be invested by the home-owners and how much the energy company needs to invest. The figure shows that in case of a limited target the owners pay most of the costs themselves. As the target is raised the energy company needs to take on a larger part of the costs, because otherwise they will not be able to find enough participants. In the end, the target may have become so high that, theoretically speaking, more than 100 % of the investment costs need to be paid as premium by the energy supplier. It should be noted that the exact amounts that will be needed strongly depend on the used assumptions, so figures presented should be seen as indicative.

The fact that households are not forced to take unprofitable measures does not mean that a white certificate system is beneficial for all households. Energy suppliers will need to recover the costs required to make households participate. One way to do this is to pass the cost through to the energy price. This means that the costs of the companies are spread across all energy users. Homeowners with intensive energy use benefit from complying with an offer made by an energy supplier. They have relatively high profits due to a lower energy bill and the premium they receive from the energy supplier. Other homeowners do not profit, but they do pay for the system through their energy bill. As the enforced target rises, more resistance costs will need to be paid by energy suppliers, resulting in a more rapidly increasing energy bill. Figure 8 shows the relation between the enforced target and the increase of the natural gas price per cubic metre. The starting points of the previous figure were also used here. The natural gas price in the Netherlands was 0,56 Euro/m^3 including tax for households in 2010.

In the renting sector, not the tenants but the landlords will invest in energy saving measures. This will be partly passed through to the rent. In a white certificate system the energy company will focus on the landlord, not on the tenant. The landlord will be the one profiting from financial benefits offered by energy companies. The higher energy price will have to be paid by the tenant, including by tenants who do not take energy saving measures. The tenant thus cannot choose whether or not he wants to participate in a saving programme, but he does pay for it.

Overall a white certificate scheme with ambitious targets will lead to major costs for energy suppliers in order to get enough participants. A minority of households will benefit from such a scheme, because their house is refurbished, but the costs will be distributed to all households via the energy bill. Implicitly a majority of households will have to pay for the energy savings of a minority of households.

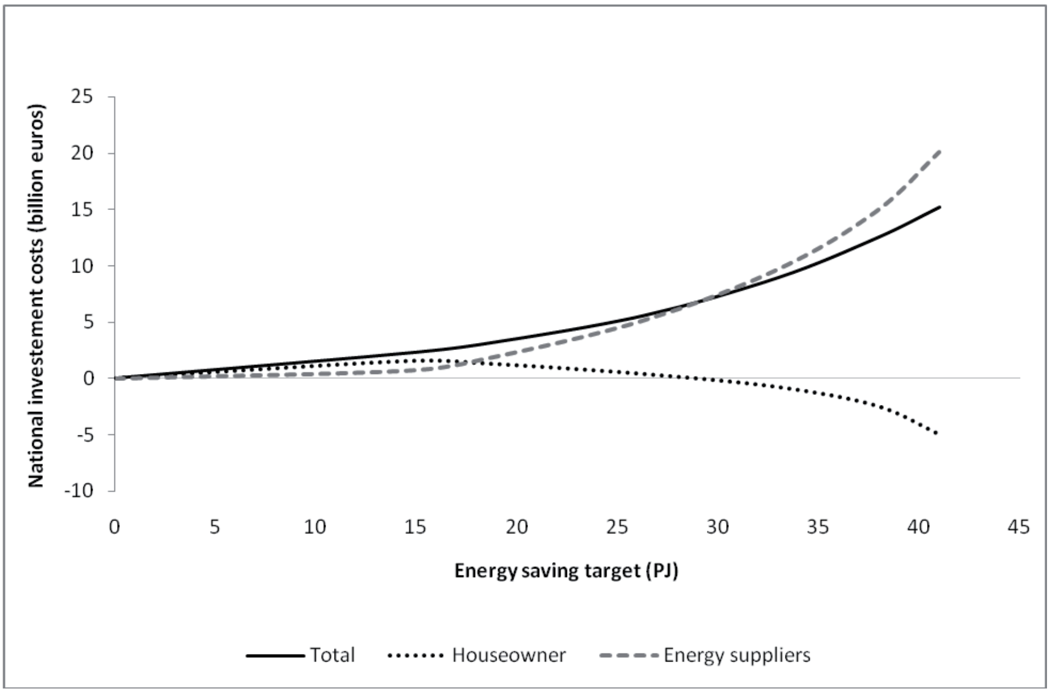

Figure 7: Relation between enforced target, total investment cost and division of costs among energy suppliers and home-owners.

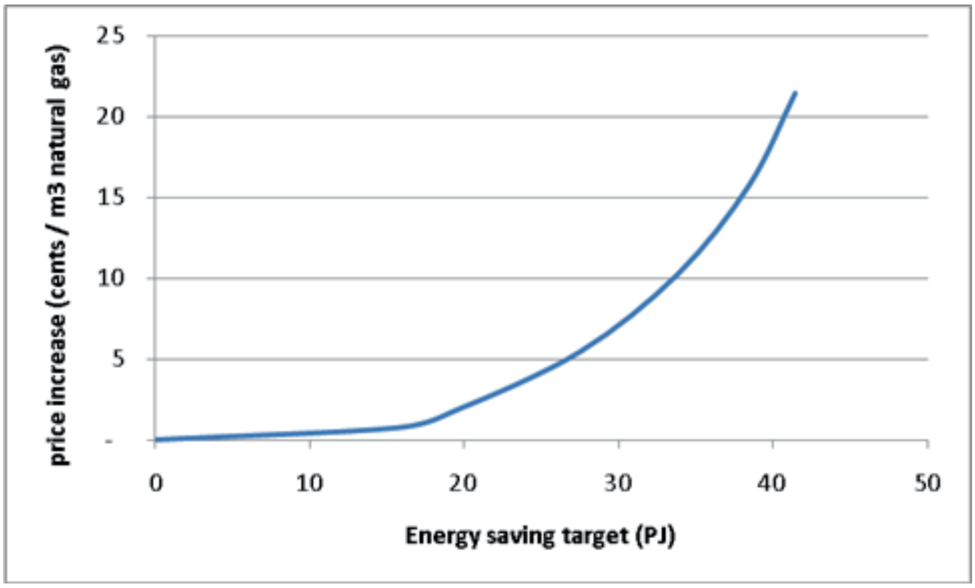

Figure 8: Relation between enforced saving target and effect on natural gas price in cents per cubic meter.

SPLIT INCENTIVES/ADJUSTING HOME VALUATION SYSTEM

Split incentives are a major barrier to investing in energy saving measures for rented homes. The owner of the dwelling, the landlord, must take technical measures and bear their cost. However, the benefits resulting from energy saving go to the tenant. In the Netherlands, a bill is approved in March 2011 to solve or limit this problem by offering landlords the opportunity to increase the rent if the score on the energy label improves.

In the Dutch social renting sector (nearly 40 % of all dwellings) the maximum allowed rent is strictly regulated. For each dwelling the number of rent points need to be determined. These points strongly depend on numerous qualitative characteristics such as size, finish and the location of a dwelling. Currently energy saving measures are valued to a limited extent in the so-called property valuation system. The new bill arranges that points are awarded based on energy labels. Table 2 indicates how many points are awarded to a label. The value of a point varies, but usually amounts to around 4.50 Euro. Based on this assumption the difference in rent costs and benefits of a dwelling with G label and a dwelling with A++ label can run up to 198 Euro for a single family house. The additional rent increase is determined such that for an average tenant the saved energy cost is higher than the rent increase.

The model was used to determine whether or not this measure solves the split incentives problem. Figure 9 illustrates the

Table 2: Valuation of Energy performance score on the Energy label of rental houses in rent.

	Points		approx. corresponding rent (euro/ month)	
	family house	multifamily house	family house	multifamily house
label A++	44	40	198	180
label A+	40	36	180	162
Label A	36	32	162	144
Label B	32	28	144	126
Label C	22	15	99	68
Label D	14	11	63	50
Label E	8	5	36	23
Label F	4	1	18	5
Label G	0	0	-	-

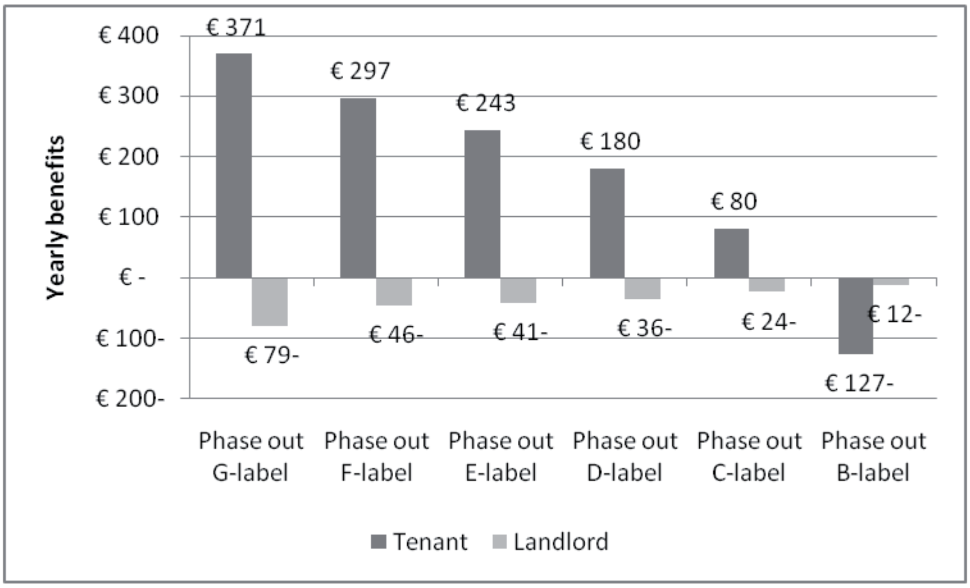

Figure 9: The benefits for tenants and landlords if landlords are forced to phase out certain label categories. Because of the adjusted valuation system for social housing the costs for landlords are limited.

effect for the tenant and the landlord if a rented home must be improved by obligation. If a dwelling with label G must be increased to the minimum level F, it will cost on average 525 Euro of finance costs annually, based on a depreciation period of 20 years. Without adjusting the rent, these costs would be entirely borne by the landlord. By adjusting the system, the landlord will now receive on average 446 Euro of additional rent per dwelling annually. In the end the landlord will lose only 79 Euro annually instead of 525 Euro. The split incentives problem has not disappeared altogether, but it has become much smaller. Social landlords have promised that, in view of their societal task, they are willing to do unprofitable investments. The limited additional cost for social landlords will probably not be barrier to investments. Despite the higher rent, the tenant will be better off in this system, receiving an additional 371 Euro annually due to the saving in the energy bill. Figure 9 also illustrates the annual costs for tenants and landlords for other targets. As the landlord takes more measures, the label will improve accordingly. The figure shows that striving for better energy labels is appealing for landlords.

Conclusions

Based on our analyses we can draw the following conclusions: On a national level there is a huge cost-effective energy saving potential in Dutch households. But whether or not specific technical measures can be installed in a cost-effective manner in individual cases depends strongly on household characteristics. We have looked at differences in dwelling type, construction periods and income categories but none of these aspects can explain the differences in cost-effectiveness of measures between households.

We conclude that heating behaviour is one of the key factors for cost-effectiveness. If the heat demand of a household is limited, the energy savings of efficiency measures are limited as well. The financial benefits of efficiency measures are equally limited in this case. In our sample we found large variety in heating behaviour and observed a strong correlation with the cost-effectiveness of energy saving measures.

There seems to be a negative correlation between technical efficiency of a house and heating behaviour of the household. In our sample we found that households living in more efficient dwellings (for instance A-label), on average have a more energy intensive heating behaviour than the average household. Households living in less efficient houses have less energy intensive behaviour. More research is needed to draw valid conclusions about the cause of this relationship.

Although heating behaviour is very important for cost–effectiveness, it is difficult for policy makers to take this into account in their design of policy instruments since they lack the detailed information to diversify their policies based on heating behaviour. As a consequence, mandatory standards that are based on technical properties of houses will have negative financial effects on many households. If mandatory standards are based on standardised assumptions on cost-effectiveness, as for instance intended in the EPBD recast, households with less intensive heating behaviour will be forced to do uneconomical investments. White certificate schemes give more freedom for home-owners to choose whether or not they want to install saving measures and do not force them to do uneconomical investments. But energy suppliers will have additional costs in such a system to make household participate. These costs could be distributed to all households via the energy bills. In this way households that do not profit from energy savings nonetheless implicitly contribute to the costs. Indicative calculations show that these costs could be significant if ambitious energy saving targets are set.

We calculated the effect of adjusting the Dutch rental legislation. These recently approved changes are designed to minimise the split incentives problem that exists if energy efficiency measures are installed in rental houses. We found that the intended link between Energy performance certificates and the maximum rental price would successfully reduce the negative financial effects for landlords when investing in energy saving measures. Despite higher rental prices, the average tenant still benefits from lower energy bills.

We've shown that mandatory instruments for energy efficiency in households can have unintentional, negative cost effects. This doesn't mean that these kinds of instruments should be abandoned all together. Undoubtedly there's a big cost-effective potential for energy efficiency in the European housing stock. If policy makers become more aware of the consequences of policy instruments for individual households they can make better choices in how to address this potential. In our research we've found that whatever instrument is chosen, there will always be groups of households that will be harmed financially. This problem could partly be overcome if the heating factor described in this paper, is used as an additional criteria for mandatory improvements at times over renovations. Households that can prove with both an EPC and energy bill that their energy consumption is far less than theoretically expected, could be relieved from this obligation. With these dispensations from the obligation the group of households that not benefits can be decreased to politically acceptable levels. Another issue, not discussed in this paper, should be noticed as well. There will be groups of households, that aren't able to finance the up-front costs for energy efficiency measures. Therefore obligations should be combined with financial instruments to offer support for low-income households.