Do energy efficiency investments lead to lower household expenditure?

Detailed analyses of the Dutch energy efficiency potential in 'real' households

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

Introduction

Energy efficiency measures are often seen as a way to save on energy bills, thereby lowering household expenditures. This is true if the savings outweigh the costs of financing these investments. Calculations on cost-effectiveness of energy efficiency measures are often based on abstract assumptions. On the one hand, economic discounting methods are commonly used to calculate investment costs. On the other hand, most of the time the expected savings are based on theoretical models used for calculating energy consumption in households.

Real cost-effectiveness depends on a variety of specific characteristics of households. In reality, the way people finance energy efficiency measures differs and what is more important: energy savings depend to a large extent on specific technical and behavioural characteristics of individual households.

In this paper, we take a closer look at households in the Netherlands. The paper shows that there is a large cost-effective potential for energy savings, but that there are major differences between households. It will explain that heating behaviour of individual households should be taken into account. The paper will also address the adjusted Dutch rental price system, which offers a solution for the split incentives problem that used to hinder energy efficiency investments in social housing.

Methodology used

ECN (the Energy research Centre of the Netherlands) has developed a model to analyse the variation among households. The model consists of different elements as described below.

1. *Random sample survey households*

The so-called WoON 2006 survey contains information about family characteristics such as number of family members, income, taxes paid, energy use, et cetera, for over 4700 Dutch households.[1] For the same households, auditors have drawn up an energy performance certificate for each respondent's house 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 in order to get a representative indication of the Dutch housing stock for the year 2006.

2. *Packages of energy efficiency measures*

Engineering agency DGMR has mapped which energy saving measures are suitable for each of the more than 4700 respondents and how this would translate in terms of energy saving.[2] Not only the effects of individual measures have been calculated; all combinations of measures, so-called packages of measures, have also been examined. A total of on average 60 different packages have been calculated for each respondent. This way a detailed overview has been made of which technical measures would be feasible as well as the saving potential of the total Dutch housing stock.

3. *Calculating costs and benefits*

---

[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

A calculation module designed by the Energy research Centre of the Netherlands (ECN) calculates the costs and benefits of the saving packages and subsequently selects the most attractive saving package.[3] The costs of each package are based on commonly used cost indicators[4] that are derived from real market figures.

To get a feel for real costs, we looked at common ways to finance these investments in reality. For owner-occupiers we used a depreciation period of 20 years and a mortgage loan with 5% interest. The Dutch fiscal system of mortgage interest relief 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, which offers financial support to tenants with low incomes, has also been taken into account.

The financial benefits of each package were 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.

4. *Selecting the most appealing saving packages*

Households or landlords can choose from different saving options. The costs and benefits of each saving package are known, thus enabling identification of the (financially) most appealing saving options for each individual household. Depending on the model input, different packages can become most favourable.

Cost effective potential

Households in the Netherlands spend on average 5.9% of their net income on energy for heating (both space heating and hot water). Figure 1 shows that this share varies significantly among households. The same is true for the cost effective savings that can be achieved in different households. In our analyses we looked at ways to cut spending on energy use for heating by taking technical measures. 20% of the households are unable to reduce these costs in a cost-effective way. The other 80% of households can save on average 22% on their energy costs through these technical measures alone.

Figure 2 shows that some households can save to over 80% while others hardly save anything. If we take financing for the investment into account, the average saving on living expenditure (net mortgage or rent + energy costs) is 4.1% (see Figure 3).

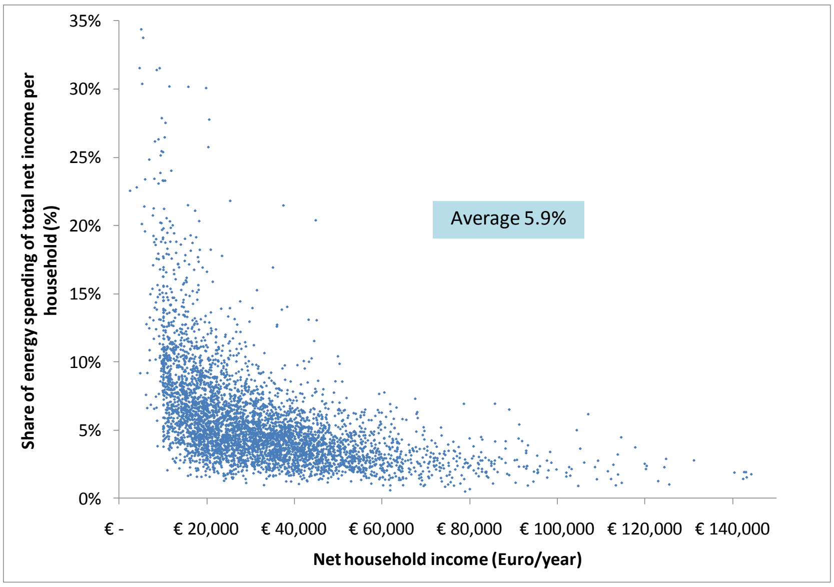

Figure 1 Diffusion of energy costs as share of net income of households

[3] Each saving package contains information about square metres, flooring, facade and window insulation and heating system.
[4] PRC kostenmanagemen (2010), Actualisatie investeringskosten Maatregelen epa-maatwerkadvies Bestaande woningbouw 2010

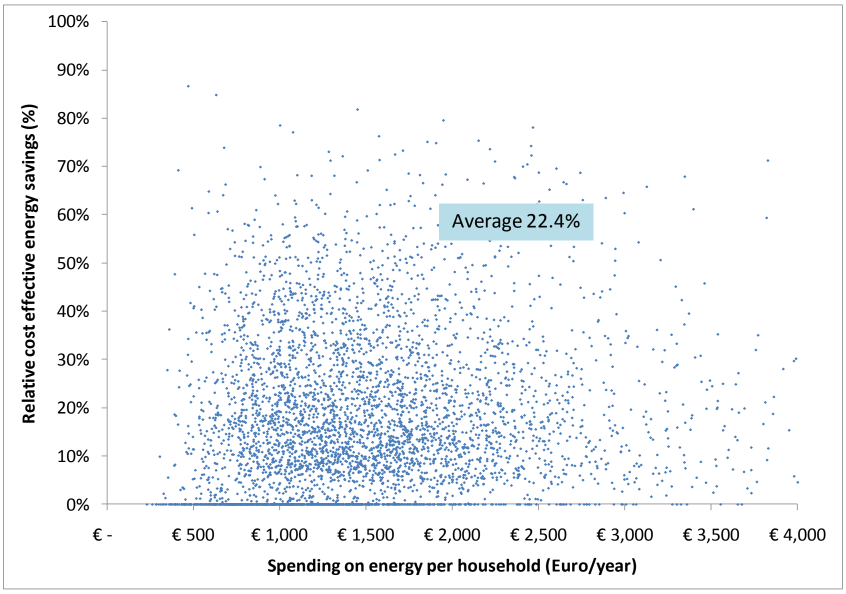

Figure 2 Diffusion of relative cost effective savings on energy costs in households

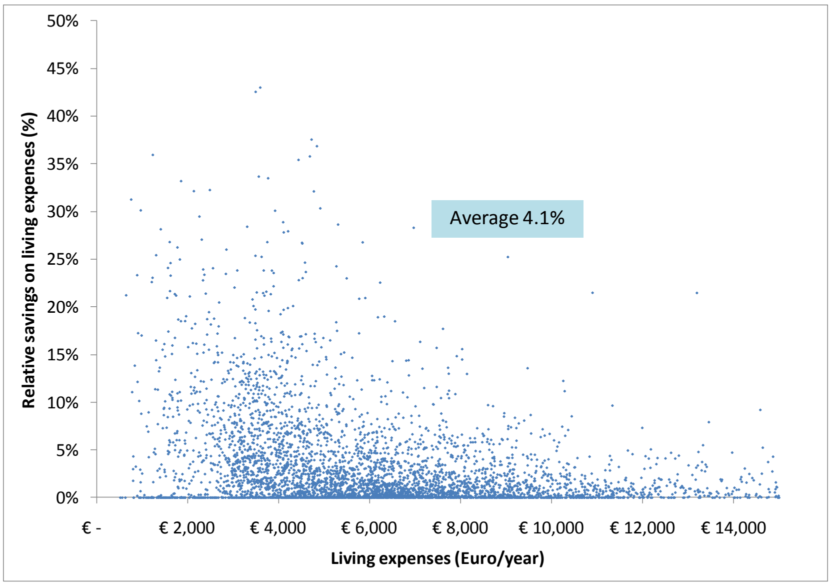

Figure 3 Diffusion of relative savings on living expenditure because of energy savings in households

Heat demand of households explains variety in cost-effectiveness

To explain this huge variety, we looked at different technical energy efficiency measures. Figure 4 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 for each individual household. 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.

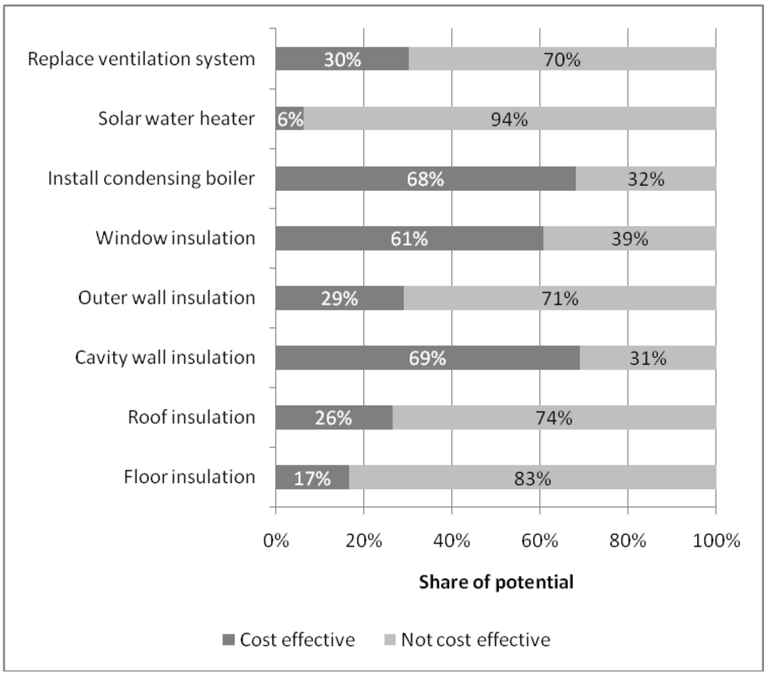

Figure 4 Percentage of the number of households where saving measures can be taken, either or not in a cost-effective manner.[5]

Based on these results, we can draw the conclusion that cost-effectiveness is not solely linked to technical measures and that we cannot use national averages to determine which measures will be cost-effective and which ones not.

We have conducted targeted research to identify specific characteristics of households or dwellings that could cause the observed differences. 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.

Determining relative heat demand of households

The energy use of each of the respondents in the random sample survey is available from databases of energy companies. These are the actual meter readings and therefore reliable data about actual use. 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 European 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.[6] 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

[5] For reasons of clarity we presented individual measures in this figure. In our study we did not only 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.

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

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 household 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.

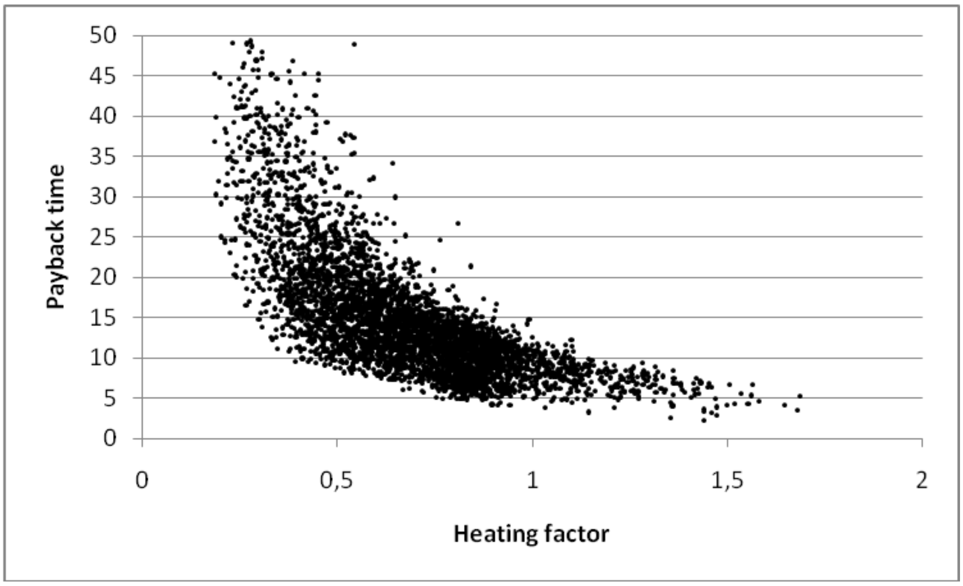

Figure 3 Relation between heating behaviour (expressed as relation between actual and theoretical use) and payback time for installing low-E glazing

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 the occupant's behaviour. Corrected for technical characteristics of the dwelling, the heat demand varies strongly among households.

Policy makers should be aware of these large differences if they are considering to force people to invest in energy efficiency measures. There is a major risk that people are forced into uneconomical investments if policy measures are not tailor-made.

Split incentives / adjusting home valuation system

Many low income households live in rental houses. Saving on energy costs is a good way to improve the financial situation of these households, but split incentives are a major barrier to investing in energy saving measures for rented homes. The owner of the dwelling, the landlord, can implement technical measures and will have to bear their cost. However, the benefits resulting from energy savings go to the tenant. In the Netherlands, a bill was 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.

40% of Dutch housing is owned by social housing associations. These are private non-profit organisations that provide households with affordable housing. The maximum rent allowed for this sector is strictly regulated and based on rent points. 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 this so-called property valuation system. The new bill arranges that points are awarded based on energy labels. 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 label G (the worst category) and a dwelling with label A++ can run up to 198 euro per month for a single family house. The additional rent increase is determined in such a way that for an average tenant the saved energy cost is higher than the rent increase.

The ECN model was used to determine whether or not this measure solves the split incentives problem. The figure below illustrates the 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 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 housing associations 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 a 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 on 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.

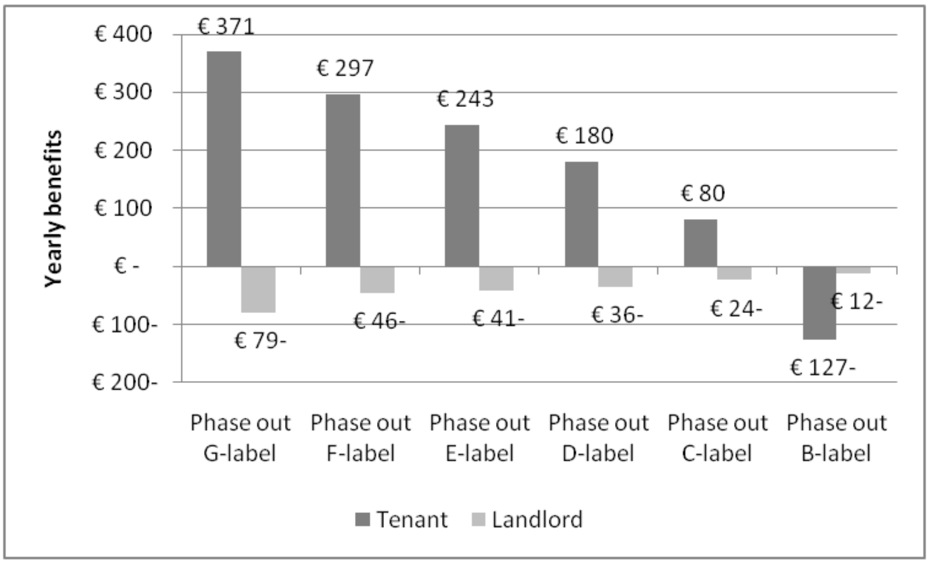

Figure 9 The benefits for tenants and landlords if landlords are forced to phase out certain label categories. Because of the adjusted valuation system for social housing, the costs for landlords are limited.

Conclusions and policy implications

Based on our analyses we can draw the following conclusions:

- In the Netherlands, the total share of energy spending as part of the total income is relatively low in comparison with other countries. This is partly because of large energy efficiency campaigns in the 1980s and a large penetration of condensing boilers (85% of all dwellings have one). Nevertheless we found that 80% of Dutch households can save on average 22% on their energy costs in a cost-effective way by taking technical measures. If we take financing into account, this leads to a net decrease of living expenditure of 4.1%. Based on this average, energy efficiency measures can have a (small) positive effect on household expenditure. Some households may experience a large effect, but other households may experience a negligible effect.

- The differences in cost-effectiveness are mainly due to differences in heating behaviour. Before starting to stimulate or even enforce investments in energy efficiency measures, policy makers should be aware of these differences among households. Otherwise, there is the risk of forcing households to do unprofitable investments. Although the findings in this paper are solely based on Dutch data, the notion that individual differences are very important for cost-effectiveness are valid for other countries as well. In the recast of the European Energy Performance in Buildings Directive (EPBD), the European Commission introduced cost-optimality as a criterion for obligatory energy efficiency investments in buildings. If differences between household characteristics are not taken into account, this could lead to an unintended rise of household expenditure.

- The adjusted Dutch system for rental prices, in which maximum rental prices are linked with energy efficiency performance, seems to be a good solution for the split incentives problem in social rental housing. On average, tenants will be better off after energy efficiency improvements. The savings on energy costs outweigh the extra rent that must be paid in the new system. Landlords can get most of their investment back via additional rent income. In the new system there is an incentive for landlords to make additional investments in energy efficiency.