 ISBN: 9789052693958

COST INFORMATION IN ENERGY BILLS FOR HOUSEHOLDS EFFECTING THE ADOPTION OF ENERGY TECHNIQUES

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Abstract
Financial appraisal is an important aspect in adopting techniques that reduce the (fossil) energy use of buildings. When financial appraisal of an energy technique takes place, fixed prices for the form and amount of energy are often used and are multiplied by the estimated amount of energy savings. However, after a certain time period an energy bill for the user of a building only partially shows variable prices depending on the form and amount of energy. Many costs mentioned by a common energy bill are time related or are related to the national political regime. Infrastructural costs depend on the type of connection you have to the grid. These costs form an annual fee. The VAT or additional energy taxes that need to be paid, depends on the political regime and are often expressed in a surcharge in terms of percentage. This paper focus on the differences between marginal and average energy costs and the differences in variable and fixed energy costs. The impact price differences have for the financial appraisal of energy saving techniques for multiple actors is shown by conducting a comparative study on energy bills. It shows that marginal energy costs are significantly lower than average energy costs.

Keywords: investment appraisal, energy costs, consumer, energy bill

INTRODUCTION

Within the European Union (EU) the energy use by the built environment is more than 40% of the total energy consumption (European Council, 2002). Many measures exist and are being developed to reduce the energy use of residents and their houses. Nevertheless, during the last decades Dutch residents seem to be confronted with increasing electric energy use and increasing energy prices. In the time period 1985-2008 the average electricity use of a Dutch household increased by 25.8% (EnergieNed 2010a). According to Statistics Netherlands (2011) the energy prices for natural gas and electric energy more than doubled in the time period 2000-2009. The average natural gas consumption per household was reduced by 34% in 2008 compared to 1985 (EnergieNed 2010a).
Multiple scholars (e.g. Shin, 1985; Hutton et al, 1986; Wilhite & Ling, 1995; Edelstein & Kilian, 2009) paid attention to the relation between energy use and energy prices. On the one hand much research was conducted using the energy bills of households, offering valuable data regarding the annual energy use and energy costs for a household and house with specific characteristics. On the other hand, focusing on the development of energy measures to reduce fossil energy use another group of scholars and practitioners can be distinguished

that uses average energy prices to give insights in the financial savings of the introduced measure. Boonekamp (2007, p. 137) states that the financial *benefits are saved energy times mean price*. The reduction in energy costs by adopting new energy measures is often computed based on energy use and costs in the past as expressed by energy bills of the household where the energy measure is introduced.

In 2002 two Swedish studies focused on the preferences of customers regarding their electricity bills (Sernhed at al, 2003). The study of the Swedish Energy Agency showed that nearly 90% of the responding households wanted to be alerted, when their energy use suddenly increases. Approximately 75% indicated that they want to have a graphical presentation of the actual energy use compared to the energy use in the same month one year earlier. Around 65% wanted to have tips to reduce the energy use and just about 50% indicated that they wanted to have comparative statistical information from a comparable household.

Research of Wilhite & Ling (1995) in Norway already showed that better feedback on energy bills led to a more energy-conscious consumer. In the third year of their experiment the group of consumers receiving a more informative energy bill reduced their energy use by 10% compared to a control group receiving a traditional energy bill. The principle of providing information about the energy use and about energy saving via an energy bill is a form of indirect feedback (Darby, 2006). The immediate information from a meter or monitor showing the current energy flows in a building is considered to be direct feedback.

In order to know what the actual financial benefits of an energy measure are, one needs to know how energy costs can be influenced by residents and energy techniques. Therefore, we wonder 1) what developments there are regarding energy prices and 2) how the constitution of energy bills and the adoption of energy techniques by households are related. This paper presents a research on energy costs in energy bills for Dutch households. More than eighty energy bills were collected addressing the energy use and costs of seven households over multiple years.

The following section addresses the research methodology. Section three describes four categories of costs mentioned in the energy bills for consumers. Section four sets out the general developments regarding energy prices for the different cost categories. In section five the results of the empirical research among seven households are addressed, before closing the paper with a section six stating the conclusions.

RESEARCH METHODOLOGY

To learn about the composition of energy bills and the costs specified in energy bills, multiple energy bills were collected. The energy bills are related to seven cases of Dutch dwellings (see for specifications Tabel 1).

Table 1: Specifications of the case study objects (see for more details Entrop et al, 2010).

	House 1	House 2	House 3	House 4	House 5	House 6	House 7
Year of construction	1925	1939	1948	1964	1972	1982	1992
Building type	Detached	Row	Semi-det.	Row	Row	Row	Semi-det.
Habitants	5	5→2	2	2→1	2	2→4	2
Total floor surface (m^2)	170.95	102.74	145.04	148.74	174.98	100.45	124.17
Surface shell (m^2)	440.2	196.9	262.1	296.2	214.1	158.3	232.5
Energy Index	1.87	1.85	2.46	2.11	1.76	1.41	1.02
Energy Label	D	D	F	E	D	C	A

Due to differences regarding building characteristics and household characteristics these houses also have different energy usages regarding quantity and form. For example cases 6 and 7 do not use natural gas, because they are connected to district heating. Based on building characteristics House 7 can be regarded as the most energy efficient object and House 3 is the least efficient. This is expressed by an Energy Index and Energy Label as is being used all across Europe, since the introduction of the European Energy Performance of Buildings Directive (European Council, 2002).
The households provided more than eighty energy bills from the time period 1987-2010. The energy bills were dispatched by nine different companies, namely Cogas, Elektran (nowadays MainEnergy), Eneco, EnergieDirect, Essent, GreenChoice, MainEnergy, Nuon, and PNEM (nowadays Essent).

Some difficulties exist when you want to compare energy costs of different households:
The format of the energy bills differs per energy company. The sequence of the individual services will for example differ. Some companies directly add Value Added Tax to the costs for individual services mentioned in the energy bills. Other companies add up the Value Added Tax in the end to the total sum of costs. For this reason it is necessary to specify some universal cost categories, which will be the subject of the next section;
The form and amount of used energy differs per house. District heating, natural gas and electric energy are three forms of energy commonly used in the Netherlands, but each can be used for different purposes and in different amounts. When the financial benefits of energy measures are addressed, it is therefore important to reflect on the way the energy price per m^3, per kWh and/or per MJ was calculated and which variation can exist in regard to this energy price. An electric conversion rate of 3.6 MJ/kWh was used, so no compensation for the electricity production was incorporated. A conversion rate for natural gas of 35.17 MJ/m^3 was used, being the upper caloric value of natural gas in the Netherlands.
The time periods will differ per house and are seldom exactly one year. An additional difficulty in this matter is that electric energy use and natural gas consumption are disproportionate to the number of days, because of differences regarding ambient temperature, wind speed and the availability of natural daylight. When collecting the data, start dates and end dates of the time periods specified in the energy bills were listed. In this paper this specific issue is of little relevance. The time periods were assigned to calendar years by means of rounding off.

Attention will be paid to the composition of the costs, developments regarding price levels and to the level of flexibility to influence the energy costs being a household. The last aspect will be important in financially analysing energy measures that reduce the energy use or make the energy use more sustainable in terms of the use of renewable sources.

COST CATEGORIES ON ENERGY BILLS

The basic raison d'etre of an energy bill for an energy company is to receive payments for the delivered product being a certain amount of fossil fuels, thermal energy and/or electric energy. From the point of view of the customer an energy bill needs to specify the delivered product or products, the costs per product (including and excluding VAT) and details of how the payment needs to take place. The basic principle underlying an energy bill does not differ from a bill for clothing or groceries. However, big differences are 1) clothing and groceries are tangible and energy is not and 2) clothing and groceries are directly paid for. The costs of energy use are often billed once a year, after doing eleven monthly payments in advance.
The studied energy bills show many different subjects where the consumer is billed for. In the past it was common to incorporate the costs of cable television and radio. Besides these not to energy related costs, one of the energy bills still mentions up to 23 different costs that are related to the household's energy use.

Analysing the Dutch energy bills, the different energy costs can be divided in four main categories:

1. Product costs: costs for consuming fossil fuels or using electric energy;
2. Transport costs: costs related to the transport and infrastructure enabling the provision of fossil fuels and electric energy at a certain address or connection;
3. Measurement costs: costs involved in measuring the amounts of delivered fossil fuels and electric energy at a certain address or connection;
4. Taxes: additional costs due to legislation, strongly depending of the political regime.

Comparing the Dutch energy bills with some Australian, Swiss and German energy bills of eight different companies, it shows that in these countries the measurement costs are not addressed by the energy bills. In general it can found that the number of different costs in these foreign energy bills is smaller.

Product costs

Natural gas is the most common used fossil fuel in the Netherlands to heat living space and heat tap water. In many dwellings natural gas is also used for cooking. Nevertheless, electrified ways of cooking became more popular in the last decade due to the introduction of multiple new systems using induction and ceramics.
A Dutch user of electric energy can choose to be priced based on a single tariff or a double tariff. During night time the electricity prices are low and during day time high. Depending on consumer behaviour and specific energy prices, a single or double tariff can be financially preferred. Besides these variable costs, fixed annual costs for delivering the electric energy are charged.
Four percent of the approximately seven million dwellings is heated making use of district heating (EnergieNed, 2010a). In this case study houses number 6 and 7 are connected to district heating, representing this category of dwellings. The price of heat is every half year calculated on the basis of a comparison between a house connected to the gas grid and a house connect to district heating. An averaged electric energy use and an averaged natural

gas use and their accompanying prices are compared to the situation of a dwelling connected to district heating. By using this method the energy companies and the government try to guarantee that in both situations the owner needs to pay the same price for fulfilling his or hers energy needs. The three main subcategories of product costs are described in Table 2.

Table 2: Different subcategories of product costs involving energy.

Cat	Variable	Description
Product	Price of producing and providing natural gas	Natural gas is provided for a price per cubic meter €/m^3 and a relatively small annual fee €/year. In the Netherlands the price of natural gas is related to the international oil price. Besides these variable costs, some fixed annual costs for delivering the natural gas are charged €/year.
	Price of producing and providing electric energy	Electric energy is provided for a price per kilowatt hour €/kWh and a relatively small annual fee €/year. In general electric energy is being produced by making use of natural gas, coal and biomass. A single or double tariff system can be applied. The latter results in a relatively high tariff during daytime and a low tariff during night time
	Price of producing and providing heat	Thermal energy for households is provided for a price per gigajoule €/GJ based on the Not More Than Different principle, stating that district heating should not be more expensive to consumers than using natural gas directly for heating purposes.

Transport costs

The Netherlands, with a surface less than 34.000 km^2, have a dense natural gas network with a total length of almost 139.000 km to provide 6.981.100 connections in buildings natural gas. The electricity network encompasses 259.241 km and 7.872.000 connections. The multiple small and large scale district heating networks have a combined length of approximately 4.711 km (EnergieNed, 2010a). The costs for the infrastructure are billed on the energy bills as described in Table 3.

Table 3: Different subcategories of costs involving the transport of energy forms.

Cat	Variable	Description
Transport	Price of transporting natural gas	Infrastructural firms maintain and improve the gas grid. A price per cubic meter of natural gas €/m^3 and/or an annual contribution per connection €/year needs to be paid by the consumer to the network company.
	Price of transporting electric energy	Infrastructural firms maintain and improve the electricity grid. A price per kilowatt hour of electric energy €/kWh and/or an annual contribution per connection €/year needs to be paid by the consumer to the network company.
	Price of transporting heat	Based on the principle that owners of a house connected to a gas grid pay the same connection costs as a house connected to district heating, house owners will pay an annual contribution for their connection to the provider of district heating €/year.

Measurement costs

In all buildings with a connection to the natural gas network and to the electricity grid meters are installed to measure the amount of energy used. These meters are owned by companies applied to measuring natural gas and electric energy flows. Compared to the other costs the measurement costs are in a standard household relatively low. In the case of district heating

the costs for measuring the energy use are incorporated in the delivery and transport tariffs (see Table 4).

Table 4: Different subcategories of costs involving the measurement of energy use.

Cat	Variable	Description
Measurement	Natural gas meter	An annual rent needs to be paid by the consumer for using a natural gas meter €/year. Maintenance costs and costs for reading the meter to check the actual energy use of households are included in the tariff.
	Electricity meter	An annual rent needs to be paid by the consumer for using an electricity meter with one or two counters for a low tariff and high tariff pricing system €/year. Maintenance costs and costs for reading the meter to check the actual energy use of households are included in the tariff.

Costs due to taxation

In the time period 1987-2010 multiple forms of energy taxes were introduced and one has already been abandoned. Energy companies function as an intermediate in collecting these taxes. At this moment the Regulating Energy Taxes (RET; Regulerende Energiebelasting) and Value Added Tax (VAT; Belasting Toegevoegde Waarde) form the fourth category of energy costs (see Table 5).

Table 5: Different subcategories of costs involving taxation of energy use.

Cat	Variable	Description
Taxes	Regulating Energy Taxes (RET)	In 2010 a standard household pays € 0.1114 per kWh of electric energy (excluding VAT) and € 0.1629 per m³ of natural gas (excluding VAT) to the government.
	Tax Credit Regulating Energy Taxes (RET)	An annual tax credit applies for the use of electric energy of € 318.62 (excluding VAT) per household per year.
	Value-added tax (VAT)	The value-added tax accounts for all (energy) products and the regulating energy taxation. In the Netherlands the VAT rate is 19 %.

GENERAL DEVELOPMENTS ENERGY COSTS

The average electricity use of a Dutch household was 2829 kWh/year in 1985 and 3558 kWh/year in 2008 (EnergieNed, 2010a). According to Statistics Netherlands (2011) the electricity prices increased from 0.278 €/m^3 for natural gas and 0.125 +/- 0.005 €/kWh for electric energy in 2000 to 0.591 €/m^3 and 0.282 +/- 0.019 €/kWh respectively in 2009. The average natural gas consumption per household was reduced from 2475 m^3/year in 1985 to 1625 m^3/year in 2008 (EnergieNed, 2010a).

The early energy bills in our collection show that consumers were billed for delivery costs only. Variable delivery costs per cubic meter and per kilowatt hour and relatively small fixed charges were billed for natural gas and electric energy. In later years 2000-2005 it can be seen, depending on the specific energy company, that variable and fixed costs for the transport of natural gas and electric energy use were charged for using the grids.

The variable costs for transport came to an end by the first of January 2009, when a fixed annual fee was set based on the capacity of the individual connection. Depending on the specific network provider the fixed costs for a connection to the natural gas grid were in 2010 approximately € 100,- to € 110,- per year for a basic connection up to 10 m^3/h. In the same

year the fixed costs to be connected to the electric energy grid were approximately € 160 to € 180,- per year for a basic connection of 3x25 A or 1x40 A.
The energy bills indicate that measurement costs needed to be paid as a rent for the energy meters starting in the time period 2002-2005. These fixed prices gradually increased to approximately € 16,- to € 20,- per year for a gas meter. The fixed prices for electric energy meters move around € 25,- per year. These costs also include labour costs, when the meters need to be replaced or when the meters need to be read.

Table 6: Energy taxation in the time period 1987-2010 (a.o. CBS, 2010)

Year	Regulating Energy Taxes Gas €/m^3	Regulating Energy Taxes Electricity €/kWh	Environmental Quality Electricity Production €	Discount Taxes €	Value Added Tax %
1987-1988	-	-	-	-	20.0
1989-1991	-	-	-	-	18.5
1992-1995	-	-	-	-	17.5
1996	0.01452	0.01340	-	22.34	17.5
1997	0.02902	0.01340	-	33.94	17.5
1998	0.04325	0.01340	-	45.32	17.5
1999	0.07251	0.02220	-	75.77	17.5
2000	0.09448	0.03720	-	105.34	17.5
2001	0.12025	0.05830	-	141.58	19.0
2002	0.12400	0.06010	-	142.00	19.0
2003 January	0.12850	0.06390	-	142.00	19.0
2003 July	0.12850	0.06390	34.00	176.00	19.0
2004	0.14290	0.06540	39.00	181.00	19.0
2005	0.14940	0.06990	52.00	194.00	19.0
2006	0.15070	0.07050	52.00	197.00	19.0
2007	0.15310	0.07160	-	199.00	19.0
2008 January	0.15540	0.07270	-	199.00	19.0
2008 July	0.15540	0.07520	-	199.00	19.0
2009	0.15800	0.10850	-	318.62	19.0
2010	0.16290	0.11140	-	318.62	19.0

Taxes are strongly related to the political regime. In the time period 1987-2010 households needed to pay the common Value Added Taxes of a percentage of 17.5 % up to 20 % (see Table 6). In 1996 the Regulating Energy Taxes were introduced, nowadays often referred to as Energy Taxes. These taxes need to be paid per kWh of electric energy and per m^3 of natural gas and was increased up to € 0.1114 per kWh and € 0.1580 per m^3 in 2010. In that same year an annual discount was given of € 318.62 on the electric energy taxes. In the first time period 1996-2000 the discount was given as a deduction on the energy use in the form of 800 kWh of electric energy and 800 m^2 of natural gas.
In the time period 2003-2006 additional taxes were introduced to finance subsidies to reduce the emissions of the Dutch electric energy production. This so called Environmental Quaility Electricity Production (EQEP; Milieukwaliteit Elektriciteitsproductie) was directly settled in the general energy discount. Nevertheless, in this time period the RET still were increased, without compromising the discount tariff.

SPECIFIC DEVELOPMENTS ENERGY COSTS OF SEVEN HOUSES

Having described the national developments regarding energy costs, this section will describe the developments in energy costs more specifically for the dwellings in the case study and per cost category.

Product costs

A standard Dutch household with a connection to the gas grid and the electricity network is free in choosing one of the many energy companies to deliver natural gas and electric energy. One is free in choosing for a sustainable or so called “green” form of energy, in choosing for a certain quality level of services and in choosing (maybe most importantly) the price of the natural gas and electric energy. In other words one can freely choose for a certain product (natural gas and electric energy) with variable and fixed costs in the category “A. Delivery” as long as one is connected to the natural gas network and the power grid.
A household occupying a house connected to district heating is bound to the company that provides the heat and maintains the local heat infrastructure. The households occupying Houses 6 and 7 are not able to choose another company (in this case Essent Local Energy Solutions BV) that can provide heat in the form of heated water. These two households can only chose their electric energy providers. Nevertheless, when a household purchases electric energy without purchasing natural gas the fixed annual costs are often relatively high, because discounts often apply when natural gas and electric energy are purchased at the same energy company. With 48 to 54% in the last three years the delivery costs form the biggest part of the energy costs for the dwellings studied.

Transport costs

Based on its location, a house is connected to a certain part of the national gas grid and electricity network. The household receives a separate bill of the regional network provider or the costs are incorporated in the energy bill of the energy company delivering and providing the natural gas and electric energy related to section “A. Delivery”. There is no possibility for a household to switch to another company, when it comes to the transport of these energy forms, besides moving to another location outside the region of the former network provider. Therefore, transport costs can not be influenced by households through the adoption of more or improved energy techniques.
In the past a major part of the transport costs were related to the amount of natural gas consumed and electric energy used. Transport costs for the houses using natural gas in the case study were around 12 to 18% of the total energy costs. Since fixed annual prices are used, these percentages are for households with an average or high energy use decreasing. Houses 6 and 7 always pay annual fees. Based on the energy use they have higher transport costs than houses connected to the gas grid.

Measurement costs

The company responsible for providing measurement equipment and services was originally related to the regional network provider. Nowadays, the possibility exists for consumers to freely choose a certified company offering these energy measurement services. Nevertheless, not many consumers are aware of this possibility and little financial benefits can be expected in switching to another company. The measurement costs are relatively little, namely just around 2 to 3 % of the total energy costs.

Taxes
Again little influence can be exerted by households or consumers to reduce this particular category of costs. The taxes are partially variable in the way that per kWh electric energy and per m^3 of natural gas a certain fee needs to be paid. In the past a fixed amount of taxes needed to be paid to improve the environmental quality of energy products and a compensating fixed tax credit was offered. The discount for 2010 is high enough to reduce the energy taxes on ± 1000 m^3 of natural gas and ± 1400 kWh of electric energy. On top of the costs in all four categories A to D Value Added Tax (VAT) needs to be paid. A household that is able to bring back its energy use to below ± 1000 m^3 of natural gas and ± 1400 kWh of electric energy, will have a discount that even reduces the VAT. Nevertheless, in Houses 1 to 5 taxes over 2009 and 2010 are 34 to 36% of the total energy costs. Houses 6 and 7 are connected to a local heat network, which means that some taxes are incorporated in the heat delivery costs.

CONCLUSIONS

The energy bills of the eight houses in the case study show that many costs involving energy use are set and need to be paid annually. When the three categories variable costs, fixed (annual) costs, and taxes are used, it can be noticed that in 2008 on average the variable costs were 57.2% of the total costs. In 2010 this value was only 42.7%. The fixed costs increased from 14.2% to 18.5%. This means that in 2010 households had fewer possibilities to influence the energy costs by adopting new energy saving techniques than in 2008.
To make the difference between marginal costs and average costs more vivid, an example will be given considering the energy use of a standard Dutch dwelling. In this situation the most appropriate figures seem to be the figures that are being used in calculating the energy prices for district heating. In this way Houses 7 and 8 from the case study can also be regarded. EnergieNed (2010b) uses the following energy usages 1372 m^3, 4116 kWh and 34.99 GJ for the year 2010. The prices are taken from the Essent energy bills of Houses 4 and 8 (price level end 2009). The total energy costs are calculated as follows:

$$P_{energy;total} = (1 + \%_{vat}) \cdot (P_{energy;delivery} + P_{energy;transport} + P_{energy;measurement} + P_{energy;taxes})$$

Table 7: Differences between average and marginal energy prices in the Netherlands

	Electric energy /kWh	Electric energy /MJ	Natural gas /m^3	Natural gas /MJ	Heat /GJ	Heat /MJ
Average costs including taxes	€ 0.1948	€ 0.0541	€ 0.6339	€ 0.0180	€ 27.89	€ 0.0279
Marginal costs including taxes	€ 0.2273	€ 0.0631	€ 0.5105	€ 0.0145	€ 20.02	€ 0.0200
Relative price difference	+16.7 %	+16.7 %	-19.5 %	-19.5 %	-28.2 %	-28.2 %
Average costs excluding taxes	€ 0.1297	€ 0.0360	€ 0.3715	€ 0.0106	€ 17.21	€ 0.0172
Marginal costs excluding taxes	€ 0.0796	€ 0.0221	€ 0.2678	€ 0.0063	€ 10.59	€ 0.0106
Relative price difference	-38.6 %	-38.6 %	-27.9 %	-27.9 %	-38.5 %	-38.5 %

Using this equation the electric energy price is calculated as € 802.- per year. The natural gas price is € 869.72 per year and the price for thermal energy within an area using district heating is € 975.97 per year. Taxes have a strong impact on the energy costs, as can be seen

in Table 7. Furthermore, these calculations show that average and marginal prices strongly differ. Also the prices per energy form can strongly differ.
This leeds us to the conclusion that due to the increasing percentage of fixed annual costs over last years, the use of average energy prices can lead to financial analysis of energy techniques that are incorrect. The financial savings will in many cases be less than expected. Our expectation is that the use of marginal energy costs will lead to a more realistic result. In general all energy costs are rising every year. However, due to the adoption of multiple energy techniques by the different households the variable energy costs can partially compensate the rising fixed or annual costs. Finally, taking into account the adoption of energy techniques, standard price inflation and increasing incomes, the total energy costs are probably increasing less significant than statistical data tries to imply.
Nevertheless, from a financial point of view of the households we expect that the adoption of energy measures can be stimulated by changing the energy bills in two ways. The first way is to improve readability of the energy bills by decreasing the number of cost components. The Australian energy bills, we shortly addressed, with only one sort of variable energy costs and one sort of annual energy costs (before adding tax) shows how energy bills for households can be simplified. The second way is to increase the influence of variable costs per unit of energy, simultaneously decreasing the influence of fixed (annual) costs, which will increase the financial effects of energy saving techniques that are able to reduce the amount of energy used.

ACKNOWLEDGEMENTS

The authors would like to thank the owners of the houses involved in this case study for providing their energy bills. Agentschap.NL is acknowledged for providing financial support of the present research (EOS LT02003).

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