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An ex-ante evaluation of a White Certificates scheme in The Netherlands: A case study for the household sector

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Abstract

Increased efficiency of energy demand is generally recognized as a very cost-effective strategy to reduce energy requirements and the related environmental impacts (e.g. the greenhouse effect). In order to improve energy efficiency the use of innovative market mechanisms, such as the White Certificates (WhC), has been proposed. The basic idea underlying this policy instrument is that specific energy saving targets are set for energy suppliers or energy distributors. These requirements must be fulfilled in a predefined time frame. The focus of this paper is on the effect on energy efficiency improvement, on the behavior of the end consumers and the market of energy efficiency measures. Furthermore, we study the possible effects of WhC in The Netherlands by means of a theoretical analysis and an empirical bottom-up model. We compare concrete energy efficient technologies in terms of cost-effectiveness and energy efficiency improvement. In combination with existing Dutch policies for energy efficiency improvement in the built environment, the contribution of this innovative scheme could enhance the accomplishment of energy efficiency targets. In this paper, two packages of energy saving measures of a WhC scheme are studied for Dutch households. The costs of these technologies are estimated through the use of different discount rates, which imply overcoming of the market barriers through the use of the WhC. A scheme that includes all available technologies as flexible options appears as a realistic solution and can generate cost effectively up to 180 PJ primary energy savings and 4550 M€ cumulative net savings in the year 2020, at a discount rate of 5%, under the precondition that the policy and administrative costs can be kept low.

Keywords: Energy efficiency; White Certificates; Households

1. Introduction

In 2003, the European Commission proposed a Directive on end-use energy efficiency and energy services (EC, 2003a). The Directive sets specific energy efficiency targets for the EU member states. The basic objective is energy efficiency improvement in the domestic and tertiary sector, industry (except for energy-intensive industry sectors, which are included in the EU Emissions Trading Directive (EC, 2003b)), and transport (excluding aviation and international shipping). The proposed Directive is aiming at an annual energy efficiency improvement of 1% p.a. for the final users for a period of 6 years.

In the past, various national and international policies have been implemented in EU countries in order to improve energy efficiency (Oikonomou and Patel, 2004). A relatively new policy instrument is the White Certificates (WhC), named also as Energy Efficiency Titles. The basic idea underlying this policy instrument is that specific energy saving targets are set for energy suppliers or energy distributors who must fulfill these requirements by implementing energy efficiency measures among their clients within a specific time frame. The fulfillment is acknowledged by means of (White) certificates. Energy suppliers or distributors, who overfulfill their targets, can sell their unused energy efficiency equivalents in the form of WhC to suppliers/distributors who have implemented fewer measures than according to their target. In this way, WhC ensure high flexibility and thus contribute to the implementation of measures that are more cost-effective.

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The WhC can furthermore be traded between *eligible* parties; these are not only energy suppliers and energy distributors (with obligations) but also Energy Service Companies (ESCOs) (without obligations). This innovative concept is also supported in the Proposal for a Directive on end-use energy efficiency (2003): "the Commission considers this to be a possible next step in a few years time and may then come forward with a proposal based on the experiences in some Member States currently developing and implementing such certification schemes".

The concept of the WhC and its implications are rather limited in the existing literature so far, mainly due to the lack of experience with this instrument. Some studies on WhC schemes refer to the identification of the participants, their possible outcome in terms of energy savings and possible market bottlenecks due to the interactions with other policy instruments (see Farinelli et al., 2005; Oikonomou, 2004; Mundaca and Santi, 2004; Quirion, 2004; Guardiola et al., 2004; Pablo et al., 2004; Pagliano et al., 2003). However, with the exception of the EU SAVE "White and Green" project, the lack of studies on the total costs for single sectors of the economy and implications of the WhC warrants further research on this field.

In this paper, a theoretical economic and techno-economic analysis is prepared, with the goal of identifying the effects of specific technologies implemented through WhC in terms of effectiveness and efficiency. In Section 2, the general economics of the WhC scheme are explained and its effects on the prices of the energy efficient technologies. Furthermore, it discusses the behavior of the end consumer as an investor purchasing the energy efficient measures. This paper does not deal with institutional issues, transaction costs and externalities. In Section 3, we provide an overview of the experience so far with WhC schemes in France, UK and Italy. The aspects discussed are the selection of suitable technologies, the design complexities, cost-effectiveness and goal achievement. This is followed by the case study of implementing such a domestic scheme for households in The Netherlands. Households have been chosen because they represent one of the target groups (next to the non-energy-intensive sectors) and because they account for a significant percentage (17%) of the final energy consumption in The Netherlands (CBS, 2003). In Section 4 a selection of technologies that can generate meaningful energy savings in the context of WhC is studied for The Netherlands. Using the Dutch ICARUS database,[1] the effectiveness and efficiency of two different packages of measures is tested. For both packages, calculations of the cost efficiency of energy conservation technologies are performed, using five different discount rates. Finally, in the last section, conclusions from the evaluation of a possible WhC scheme are drawn.

[1]Information system on Conservation and Application of Resources Using a Sector approach (ICARUS) contains information on the saving potential and costs of a large number of technologies for improving energy efficiency in all sectors of the Dutch economy (Alsema and Nieuwlaar, 2001).

2. Description of WhC scheme

2.1. Mechanism of WhC

WhC is a new policy instrument to increase energy efficiency using market-based mechanisms. The basic principle of this policy measure is that the authorities impose energy efficiency obligations on electricity and/or gas suppliers and distributors, who can then decide whether to implement energy efficiency measures or to purchase WhC, depending on their marginal costs. WhC are generated when energy savings are realized and certified. The purpose of the WhC as a policy instrument is twofold (Oikonomou, 2004):

- As an accounting tool, which proves that the requested amount of energy savings has been realized within the time frame agreed. The owners of WhC declare their savings in energy value before or after surrendering the WhC to the appropriate authorities, depending on the design of the scheme.
- For commodity trading either bilaterally or on the WhC market (Pavan, 2002), in order to provide cost-effective options for existing and new participants.

The philosophy underlying this system is to combine the guaranteed results of setting obligations (it can also be considered as a smart way of regulation) with the economic efficiency of market-based mechanisms (Pavan, 2002; Oikonomou, 2004). This will be explained in detail in Sections 2.2 and 2.3.

As shown in Fig. 1 the WhC market consists of the following participants: regulatory authority, suppliers and/or distributors of gas and electricity, ESCOs, households and brokers.

The regulatory authority plays the principal role in distributing the obligations among the participants and issuing the certificates. The participants that can request and trade WhC are:

- The *suppliers and the distributors of gas and electricity*, who have an obligation, set by the regulatory authority, to save a certain amount of energy within a specified period. To this end, the suppliers have to promote specific energy efficiency projects to the end consumers. Suppliers and distributors receive WhC and can trade them on the market.
- The *ESCOs*, who are companies that offer to reduce a client's energy cost, often by taking a share of such reduced costs as repayment for installing the energy efficiency measure and financing its upgrades. They do not receive an obligation, but can participate in the scheme after achieving energy savings and receiving WhC (Oikonomou, 2004). ESCOs participate in the

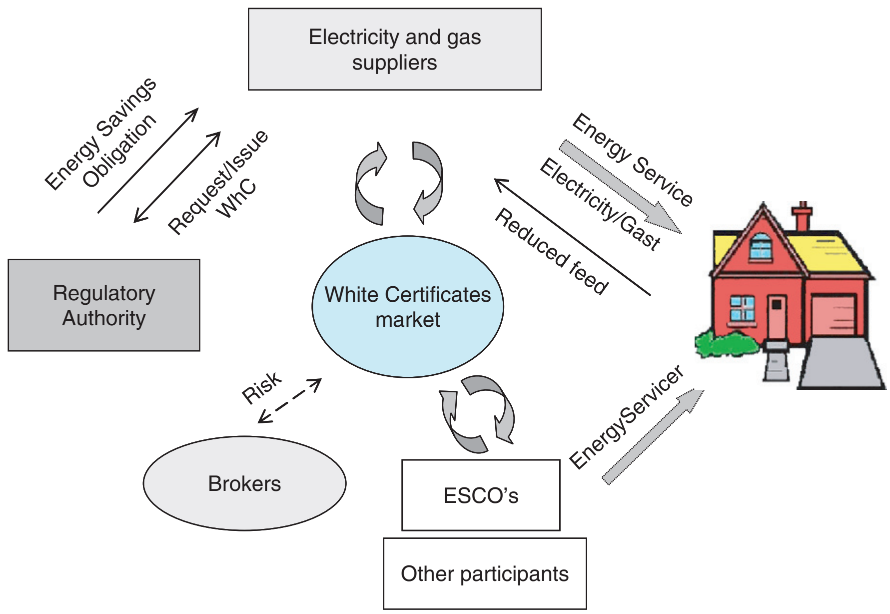

Fig. 1. White Certificate energy market.

Italian and French WhC scheme, while they are not included in the UK.

- The "other participants" indicated in Fig. 1 are entities that do not receive an obligation but can purchase and sell WhC, providing thus the necessary liquidity in the market. Examples for such entities are brokers and financing institutions, which facilitate the transactions and reduce the risk of the investments, while speculating on the price of WhC and receiving a commission from the transaction costs. The eligibility and the role of these entities differ among the existing WhC schemes. These entities are included in the UK and French WhC scheme.

Depending on the design of such a scheme the relationships among the participants differ (in theory, obligations could be also be given to the end consumers, who would then be a trading party). The consumers and end users, who are the recipients of the energy efficiency measures, benefit from lower energy bills and decreasing costs of measures, as the supply of energy efficient technologies increases and prices fall (EC, 2003a). According to market theory, the cost-effectiveness of the instrument as a whole is at its maximum, given that no externalities appear, when the marginal costs are as low as possible. In theory, the marginal costs decline with a rising number of participants and with a high number of measures, which provide greater flexibility of the WhC, and hence lower marginal abatement costs for the energy suppliers and for the economy as a whole.

The energy saving targets set for a WhC scheme are specified either in absolute terms or relative to energy consumption at the start of the timeframe. The most usual form is to set a quota. As an alternative, energy efficiency goals can be set in relative terms (e.g. MWh saved instead of % saved of sold electricity or gas; see Quirion, 2004). In any case, the target is divided among all the distributors/suppliers, resulting in concrete energy efficiency goals for each obligated participant.

2.2. Economics of energy market

Increased energy efficiency reduces the quantity of electricity and gas sold, thus leading to a decrease in the suppliers' direct sales and profits. Moreover, suppliers have expenditures related to the purchase and installation of energy efficiency measures. The financing of the whole scheme is based on mechanisms where the suppliers can recover part of their extra or incremental costs with an increase in tariffs. The extent to which the expenses can be recovered influences the diffusion of efficient technologies (Oikonomou, 2004). The efficiency of the WhC scheme will be enhanced, as long as the marginal costs of these measures equal the marginal benefits, which are represented by the electricity price.

In Fig. 2, the function of a scheme of WhC in the market is demonstrated. In this simplified case, we consider a competitive market for energy efficiency, where the energy suppliers and distributors constitute the supply side, carrying an obligation translated into energy saving measures, and the end users represent the demand side. We acknowledge that in reality such a market is rather imperfect due to distortions both from demand and supply side, but we assume competitiveness as an end effect of energy market liberalization. Examples for measures are energy efficient appliances, building components such as windows, or major energy consuming devices (Geller and Nadel, 1994). In order to depict the market effects of a

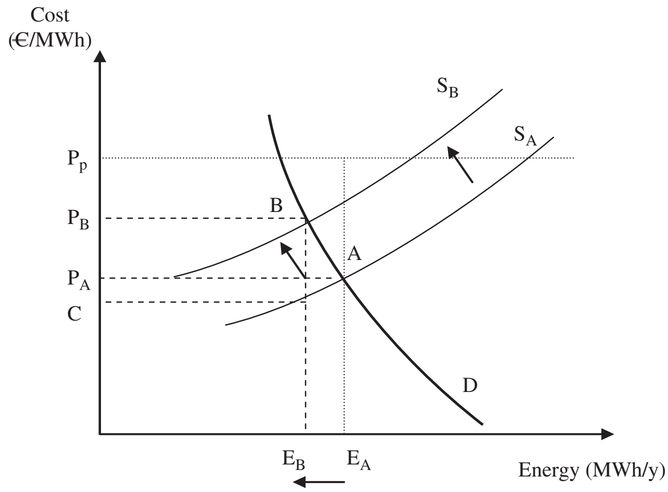

Fig. 2. Supply and demand of energy efficiency.

WhC scheme, we present a base case (S_A) and an energy savings case (S_B). In the base case, the suppliers, without obligation, sell electricity to the consumers at an equilibrium market price P_A. Due to the implementation of energy efficiency measures (as a consequence of the WhC scheme) the amount of electricity decreases from E_A to E_B. The supply curve (S_B) depicts the obligation to carry out energy efficiency projects so that the new supply curve in this case can act as a constraint at a higher cost for the supplier. According to economic theory, the electricity price decreases with lower demand; as a consequence, the consumers should pay the price C for the electricity they purchase. Since, however, the consumers are supposed to contribute to the energy efficiency projects they pay a price ranging from C to P_B. In another case, if the heaviest burden of realizing these projects is left to the suppliers and they cannot pass this cost to consumers via electricity or gas tariffs, for the part E_B the consumers contribute at price level of C. Finally, if markets are fully liberalized, the suppliers can request a cost recovery (from the consumers or the relevant authorities) for E_B (this will be analyzed further), which, if it is a full recovery, can reach up to P_B. They also acquire WhC, which they can trade with other parties in order to cover their obligations, at a price $P_B - C$, or pay a penalty instead at a price P_p.

The effectiveness of the WhC increases if they are bundled, among others, with information campaigns and other means to promote opportunities of energy saving (Farinelli et al., 2005) in order to drive the consumers demand for energy efficient measures. In a parallel market of these measures, the introduction of the WhC would reduce the relative price of the energy efficiency measures resulting in an increased demand for these goods. However, the rise of the demand may be limited. The reasons are firstly the rebound effect on the consumers behavior, which is expected to range from 5% to 50% (according to a MARKAL study for Italy on the WhC it reaches 27%, Farinelli et al., 2005. For more information see Greening et al., 2000; Binswanger, 2001; Oikonomou, 2004). The second reason is that short-term elasticity of energy use, as complemented with durable equipment, is much smaller than long-term elasticity (Velthuijsen and Worrell, 1999).

2.3. Consumer's behavior

Several literature studies have attempted to identify the consumer's preferences on energy efficiency (see Lutzenhiser, 1992; Sweeney, 1994; Nyboer and Bataille, 2000; Poortinga et al., 2003). Two basic approaches exist, as summarized by Sanstad and Howarth (1994): The neoclassical economic approach is based on the bounded rationality and the consumers choice under an income constraint and therefore assumes that in a competitive market the preferences should shift to energy efficient goods that are cost-effective; however, this is not observed in reality due to the "efficiency gap" and this may be a result of mismeasurement of costs and benefits (Sutherland, 1991). According to other authors, the main reason is the existence of market barriers and imperfections that do not allow the diffusion of efficient technologies. Market barriers are all factors that explain why consumers do not take up energy efficient technologies that are cost-effective at current prices (OECD, 2003). These obstacles include:

- lack of knowledge, know-how and technical skills,
- lack of access to capital and historically or socially formed investment patterns,
- disparity of profitability expectations of supply and demand (i.e. uncertainty of profit margins due to market forces),
- legal and administrative obstacles,
- other market barriers (investor-user dilemma, suppliers prefer activities in their core business instead of energy efficiency, etc.).

Further factors on the consumer's side from empirical studies that lead to overuse of energy and reduce the effectiveness of the energy saving policies are identified (see Hausman, 1979; Kempton and Montgomery, 1982; Yates and Aronson, 1983). Such parameters are the use of higher discount rates (than the social discount rates) in consumers' energy efficiency investment decisions, salience effects whereby excessive weight is given to psychologically vivid attributes and often-incorrect use of technology. Taking these parameters into account, we analyze in Fig. 3 the effect of the implementation of WhC on the end consumers, departing from the fundamental consumer behavior theory. Through this analysis we identify the behavior of the consumers when facing the option to choose between energy efficient or conventional technologies for their households. In Fig. 3, we assume a household that spends a part of their income (I) on energy goods in order to achieve maximum levels of utility of energy

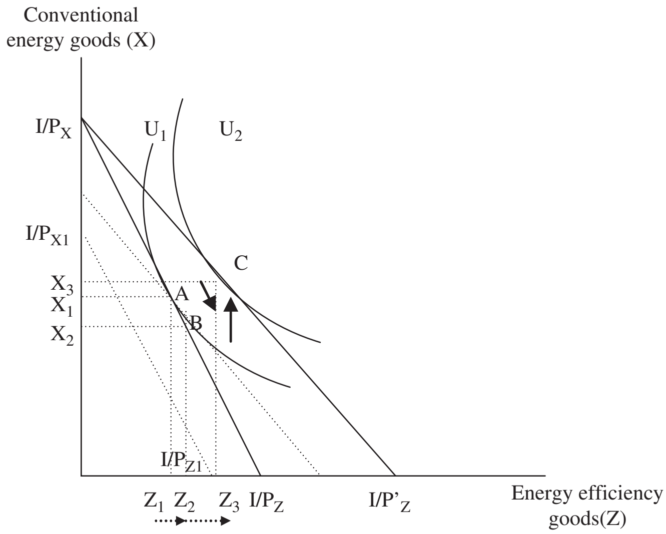

Fig. 3. Consumer's behavior in a WhC scheme.

services (heat, light, etc.).[2] This disposable income can be spent between several durable energy goods (i.e. referring to appliances and technologies) that all generate a level of utility from energy services (U_1). For our analysis we assume two general bundles of goods; the energy efficient measures and technologies that are being promoted by the WhC scheme (Z) and the standard conventional ones (X). P_z and P_x are the respective purchasing prices. According to the market conditions and the existing policies, most of the energy efficient goods are sold at higher prices, which explain *the steep angle* of income constraint line in the figure ($I/P_x > I/P_z$).[3] We furthermore assume that both X and Z are normal goods (although Z has higher income elasticity and could also be considered as a luxury good, see Poortinga et al., 2003) and entail a high degree of substitution[4] (see also Binswanger, 2001). The direct relationship of energy conservation with higher income households for various reasons (for instance higher income end users more probably own rather than rent the home) is presented in many studies (Tonn and Berry, 1986; Hirst et al., 1981; Wirtshafter, 1985). In the initial allocation of the goods, the end user maximizes his utility by purchasing Z_1 and X_1 units of the energy service goods (point A). This analysis assumes the Uniformed Consumer Hypothesis (Brill et al., 1999), whereas the consumer is not fully aware of the potential high returns in investment from purchasing Z goods. As presented in Section 2.2, one possible effect of the WhC scheme is the introduction of the energy efficient goods to the consumer through the reduction of their price (as a small percentage of the upfront investment cost), better information and overcoming traditional market barriers. The positive effect of information on energy saving behavior is tested in several studies (Brandon and Lewis, 1999; Van Houwelinegen and Van Raaij, 1989; Midden et al., 1983; Boardman, 2004). This price reduction will incur two effects on the demand response of the consumer. The energy efficient goods, hence, are at relative competitive prices with the other energy goods, which lead to the *substitution effect*. The consumer responds to the market signs and can partly substitute some energy efficient goods for other goods: the number of conventional goods decreases from X_1 to X_2, while the number of energy efficient goods increases from Z_1 to Z_2 (point B). Furthermore, as the disposable income (orientated for energy services) grows, the consumer increases consumption for *both* bundles of energy goods (Z_2Z_3 and X_2X_3; point C), achieving a higher level of utility (U_2).[5] Due to the nature of these goods, one outcome is that the income effect is higher than the substitution effect, meaning thus that the price decrease of the energy efficient goods is not an adequate parameter for shifting consumption patterns, but the rise of the real income is still considered to dominate the opportunity cost (consumers value a higher income more than shifting their consumption). Through the WhC scheme, bundled with information campaigns, the basic target is the market transformation with the diffusion of more energy efficient technologies for the end consumers of different income levels. As analyzed above, a determining parameter in the effectiveness of the scheme is the price of energy, since together with the price of the energy goods they compose the final price of the energy services. An increase in the price of energy results in a reduction of the disposable income and graphically shifts the income constraint line (I/P_x I/P_z) to lower values without leading to a significant substitution effect (new line $I/P_{x_1}I/P_{z_1}$). Finally, an important parameter that can alter at some degree the effect of the end-user's choice is the propriety housing status, i.e. if the end consumer is a tenant or owner, widely known as the landlord/tenant dilemma (see Schleich, 2004; Levinson and Nieman, 2004).

3. Experience from White Certificate schemes

Within the EU, only UK and Italy have so far implemented WhC schemes in the portfolio of policy instruments to improve energy efficiency, while France and other countries are in the preparation phase.[6] A basic

[2]This hypothesis could also be set inversely set as given a level of utility from energy services, how can the expenses of the end consumer can be minimized.

[3]The points I/P_x and I/P_z on the income constraint line represent the quantities of energy efficient and conventional goods that a consumer can purchase, when I is the income I and P_x and P_z are the prices of the two groups of goods.

[4]In this figure we assume a Cobb-Douglas utility function $u(x,z) = X^aZ^b$, where a and b are positive numbers that describe the consumer preferences on energy goods. This function is the standard example of indifferent curves that are referred as "well behaved" (Varian, 2003).

[5]This practically implies that the consumer prefers an increase of his income, rather than a decrease of the prices of energy efficient goods, in order to shift his preference towards more energy efficient purchases.

[6]The IEA-DSM group is dealing with White Certificates and their potential implementation in the EU (see http://dsm.iea.org/NewDSM/Work/Tasks/14/WhiteCertificates.htm).

distinction between these schemes lies in the different ambition levels and participating actors. A short description of these schemes follows in Table 1.

3.1. The Italian case

In *Italy*, the obligations for the energy efficiency projects are set for the distributors of electricity and gas. This system was introduced in 2001 by two legislative decrees issued by the Ministry of Industry in cooperation with the Ministry of Environment that concerned electricity and gas suppliers (including the development of decentralized renewable energy sources),[7] respectively (Pagliano et al., 2003). The scheme has commenced this year.

Table 2 presents the quantitative objectives pursued by the scheme for the improvement of energy efficiency. They are expressed in primary energy units (PJ) to be saved in comparison with the business as usual scenario for each year in the period 2005–2009 cumulated over this 5-year period.

The national targets are set as specific targets for each electricity or gas distributor who serves more than 100 000 clients (as at 31.12.2001). In more detail, the following suppliers are involved (Malaman and Pavan, 2002):

- Gas: twenty-two distributors with 9 630 000 customers out of total 16 000 000
- Electricity: eight distributors covering almost 98% of all customers

The obligation is adapted every year on the basis of the quantity of electricity and gas distributed to consumers, thereby taking into account the total national objective in the previous year. At least 50% of the obligation must be achieved by energy savings or energy efficiency improvement. The rest can be obtained e.g. via fuel switch (for example from electricity to gas), given that quantifiable primary energy savings are achieved (Pagliano et al., 2003). There are three types of certificates that are issued and traded, each one with a predefined unit value that attests primary energy savings through reduction of (a) electricity consumption, (b) natural gas consumption or (c) consumption of other fossil fuels (Pavan, 2002). In Appendix A, a list of indicative measures that the Authority for Electricity and Gas (AEEG) has applied is presented, alongside the conversion rates from final to primary energy in Italy.

3.2. The UK Energy Efficiency Commitment

In the *UK*, a system of WhC is being implemented through the Energy Efficiency Commitment (EEC) scheme in two phases, i.e. 2002–2005 and 2005–2008 (DETR, 2000; DEFRA, 2004a). For 2002–2005, the total energy reduction target is 62 TWh of fuel-standardized carbon equivalent energy (around 16 PJ, almost 1% of consumption), hence 20.7 TWh/year. Fuel standardized energy in the UK EEC refers to the energy that is adjusted to the carbon content of each fuel. These coefficients are set as: coal (0.56), electricity (0.80), gas (0.35), LPG (0.43) and oil (0.46) (DEFRA, 2004a). The target applies to all gas and electricity suppliers, which have more than 15 000 customers; in total there are 11 suppliers in the UK that cover the 99% of the energy market (Costyn, 2003). The energy suppliers have progressively relatively tighter targets when increasing their business size and activities.[8] In this scheme, the energy distributor finances a share of the total implementation costs of these energy saving projects. This share is based on the final cost and the willingness to pay (WTP)[9] of the energy consumer. The difference is the distributor's contribution, which is named *inducement cost* (DETR, 2000). The inducement cost for the supplier is higher for the customers with lower income and smaller WTP, which results in a higher burden for the distributor (more information is presented in Table 3).

The households are divided in *two groups*. The first group is the so-called *priority group*. This includes 7.7 million households comprising pensioners, aged 60 or above, occupants of social housing, receptors of disability benefits, or finally, households receiving benefits with children under the age of 16, which are also the target group of the Warm Front. The latter is the UK policy measure against fuel poverty (referring to people who spend more than 10% of their income on domestic heating).[10] This group accounts for almost 33% of total households (Pablo et al., 2004). The suppliers can implement non-structural measures, such as appliance replacement and energy efficient light bulbs where 100% inducement cost is expected. Structural measures are mainly insulation and heating, which demand renovation of the building itself. Energy suppliers are obliged to implement at least 50% of their energy savings to the priority group. On average, the suppliers cover the 80% of the cost of the structural measures for the priority group.

The *second group* covers all the other consumers. It also includes another category of consumers, mainly "near-benefit" consumers or low-income consumers, still under fuel poverty. The average contribution level for the suppliers is estimated to be just over 50% for the non-structural measures and around 40% for most structural measures. In both phases of EEC (see DEFRA, 2004a), the suppliers are not financed for introducing EEC measures,

[7] In Italy, the quota of electricity from renewable energy supply is an obligation for producers, not distributors.

[8] In order to achieve the national reduction target, each distributor's group of customers must be adjusted, according to a formula, in order to simplify the procedure of dividing up the total target between the suppliers (Oikonomou, 2004).

[9] The WTP is used as a theoretical concept in the analysis and does not refer to actual results stemming from discrete choice method. For a relevant study for energy efficiency WTP derived from a contingent valuation, see Rehn (2003).

[10] See DTI, UK Fuel Poverty Strategy, November 2001.

Table 1
Characteristics of existing WhC schemes in Europe

	UK EEC 2002–2005 Energy Efficiency Commitment	ITALY WhC Titoli di Efficienza Energetica	French WhC Certificats d' economie d' energie
Stakeholders	Electricity suppliers and (after 8 years) gas suppliers	Electricity and gas distributors	Electricity, gas, heat and fuel suppliers
Compliance period	2002–2005, 2005–2008…	Annual (2005–2009)	2006–2008
Obligation (plan)	50% from "priority group", 62 TWh cumulated fuel standardized energy savings (equivalent of a carbon target) (2005–2008)	50% from electricity/gas savings, 243 PJ (5.8 Mtoe) primary energy saved	54.7 TWh (197 PJ) lifetime discounted cumulated final energy savings over 3 years
Threshold	$\geqslant$15 000 domestic customers	$\geqslant$100 000 customers	>400 GWh/year (juridical persons) None (residential, fuel suppliers)
Reference	Number of domestic customers	Electricity/Gas distributed	Electricity/gas/heat/fuel oil distributed
Criteria	Progressively tighter for companies of increasing capacity	Linear	Update of targets every year according to market conditions
Eligible sectors and technologies	• Households • Pre-approved list of measures, can extend to new measures	• All end-use sectors • No pre-approval yet	All end-use sectors (building, industry and transport, but not measures on sites covered by EU ETS) Pre-approved measures but not fully decided
Project evaluation	Annual reports by Ofgem to Government. Following Ofgem's final report on EEC 2002–2005, Government will consider its impact, including carbon abatement.	• Deemed-savings approach • Engineering savings approach • Direct measurement approach	For standard measures ex ante evaluation based on data on technologies and sales of equipment Correction after the realization of savings (receipt of certificates)
Additionality	Suppliers must demonstrate that projects are additional (deadweight removed from targets)	• Dealt with baseline definition • Other adjustments foreseen but not yet implemented	Additionality must be demonstrated by suppliers • Obliged: any eligible action is additional • Non-obliged: turnover must not be increased or they install very innovative products
Certificates	• Savings (for gas, electricity, oil or solid fuel) • Obligations (all of part of)	• White Certificates for electricity • White Certificates for gas • White Certificates for other fossil fuels	White Certificates
Certificates lifetime	3 years	5 years (banking with quota)	10 years (banking and adjusted according to regional factor coefficient)
Trading parties	Responsible electricity and gas suppliers	All electricity and gas distributors and ESCOs	Responsible suppliers, eligible owners (i.e. building owners), other bodies (manufacturers, traders)
Penalty	Calculated as a 10% of the supplier's turnover	Proportional and greater than the investment required to compensate the non-compliance (estimated higher than 150–200 €/toe primary energy saved, i.e. 3.6–4.8 €/GJ)	At least the same price of the purchase of a certificate, estimated around 2 c€/kWh final energy, i.e. 5.6 €/GJ
Scheme financing	Cost-recovery via electricity and gas tariffs	Cost-recovery via electricity and gas tariffs (unique or differentiated, updatable)	Cost-recovery via electricity or gas tariffs Consumer's contribution expected up to 0.3–0.5% increase of their energy bill
Link with other schemes	ETS: only surplus	Not yet decided	Not yet decided

Source: Oikonomou (2004).

Table 2
Energy and gas savings targets in Italy in primary terms

Year	Objectives (PJ/year)		Objectives (MTOE/year)	
	Electricity saving	Gas saving	Electricity saving	Gas saving
2005	4.2	4.2	0.1	0.1
2006	8.4	8.4	0.2	0.2
2007	16.7	16.7	0.4	0.4
2008	33.5	29.3	0.8	0.7
2009	67	54.4	1.6	1.3
Cumulative	129.8	113	3.1	2.7

Source: Legislative Decrees, July 2004, Gestore Mercato Elettrico (5/12/2003).

since they are not anymore price controlled (no tariff structure) and they can decide the amount they can charge.

3.2.1. *Impact of the EEC*

Sorrell (2003) calculated that the price increase in energy expected after the implementation of the WhC can affect the consumers, since in real terms, the electricity and gas electricity suppliers in the market are still in an oligopolistic and monopolistic position and they can still apply differentiated pricing policies. Concerning the EEC 2002–2005, a price increase was estimated at €4.8 per fuel per year for all final consumers (around 3 €/t CO_2), excluding the priority group (Sorrell, 2003).[11] The investment costs evaluated amount to 225 million € per year, equivalent to 10€ investment per saved MWh of electricity and gas over the lifetime (Tabet, 2003). The benefits under this scheme will be returned only to the direct participating consumers in the form of energy efficient measures, while all consumers will contribute in the scheme through the price increase. For the period 2005–2008, the consumers' financial benefit from the EEC measures, in the form of lower energy bills (or increased comfort), is estimated at around 22€ per year for the lifetime of the measures. The potential non-ongoing costs to consumers (if passed on in full by energy suppliers) are estimated to be maximum 13.2€ per customer per year for both electricity and gas (DEFRA, 2004a).

In the UK, the energy suppliers have completed the third year of the program of the EEC and participate in the second phase of the scheme (2005–2008). The total energy saving objective of the EEC was 62 TWh for the period 2002–2005. The suppliers delivered 17.1 TWh of energy savings in the first year, 30.2 TWh in the second and 39.5 TWh in 2005, which in total amount to 76.8 TWh. Roughly 60% of the savings were achieved by insulation, 20% from lighting schemes and 20% from both heating and appliances.[12] There has been no actual trading between suppliers in the first year of the EEC (Ofgem, 2003).

The second phase of the EEC (2005–2008), foresees a doubling of the size of the scheme in order to achieve the higher saving targets of 130 TWh (fuel standardized lifetime discounted) or 53.6 PJ (DEFRA, 2004b).[13] Suitable measures to reach this goal have been indicated but they do not need to be further quantified since their energy savings are preset.[14] For all other measures, suppliers must demonstrate additionality in order to get the energy savings accredited. Table 3 presents the measures suggested on the basis of the target and expected annual savings, alongside with the relative burden of the households on the cost of each measure.

In Table 3, new measures, or higher ambition level between the two phases of the EEC, reveal the enhanced efficiency of the scheme. Furthermore, the cost sharing fulfills the criterion of equity, since for the most expensive measures (i.e. fuel switching) the burden of the priority group is rather limited, while for cheaper options compact fluorescent lamps (CFLs) the burden is equally shared. The total cumulative investment costs for the implementation of all the measures can rise up to 5565 M€, where 566 M€ could be the extra burden for the priority group, while the other groups can contribute up to 1563 M€.

3.3. *The French White Certificates*

In *France*, the WhC are under current discussion on a governmental level and a preliminary planning has already been suggested in the White Paper of the French Ministry of Industry (Fontaine, 2003). According to the proposed scheme, the obligations will be set to the suppliers of electricity and gas, who must either promote energy savings or purchase certificates. Energy savings can be realized in all sectors (including transport). The overall target in final energy terms is 194 PJ (54 TWh) reduction over a period of 3 years, with 122 PJ (34 TWh) from electricity, 38 PJ (10.5 TWh) from gas, 5.4 PJ (1.5 TWh) from heating and the rest from other domestic fuels. These targets will be adjusted annually, depending on the market conditions of

[11]This should be compared with reductions in real terms of 32% in electricity bills and 22% in gas bills between 1995 and 2002.

[12]Besides Ofgem (2003), there has been no recent evaluation of the second phase of the EEC yet.

[13]For future energy savings, a discount rate of 3.5% is used in order to account for the fact that savings in the future are less certain than now. The EEC 2005–2008 target is roughly equivalent to annual net delivered energy savings of 37 PJ (or almost 2% of consumption), taking account of business-as-usual deadweight and theoretical-to-actual savings (such as comfort taking). These figures depend e.g. on how suppliers actually achieve their targets in terms of the mix of measures. (C. Rohr, October 2004, pers. comm.).

[14]In the UK there is a list of predetermined indicative measures, for which the overall energy saving target is set. Information about the measures implemented is presented by the suppliers in the form of equipment and measures sold. During the course of the scheme these formed the main measures implemented, partly because energy savings had been established for them. Nevertheless, other measures can be also implemented, as long as their energy savings are independently verified and approved by the regulatory body (Ofgem).

Table 3
EEC 2002–2005 and 2005–2008 measures in the UK

Projects	Total installations from EEC (M)	Lifetime in years	Primary Energy Savings per year (GJ/unit/year) basis of target		Total EEC target-fuel standardized and lifetime discounted (PJ)-basis of target		Annual net primary energy savings (PJ/year)	Total cost per measure (€)	Consumer contribution to measure	
			2002–2005	2005–2008	2002–2005	2005–2008	2005–2008	2005–2008	Priority group %	Other groups %
Cavity wall insulation private	1.00	40	18.86	18.54	66.24	155.52	23.33	462	0	28.2
Cavity wall insulation social	0.70	40		18.00		105.84		455	33.4	35.8
Loft insulation private	0.70	30	6.62	9.76	10.44	49.68	7.14	380	0	28.4
Loft insulation social	1.42	30		6.73		20.52		383	32.9	35.3
Loft insulation DIY	0.46	30		12.02		39.96	2.43	194	25.8	27.4
Glazing E to C rated	4.50	20	-	0.11		2.52	0.38	15	13.6	27.3
Boiler end-of-life replacement with condensing boiler, A/B rated boilers	0.20	15	9.22	11.16	16.56	9.36	2.60	283	11.7	29.3
B to A rated boilers	1.00	15		4.14		16.92	4.36	73	0	0
Fuel switching	0.06	15		28.48		18.36	2.34	2637	6.7	44.4
Heating controls—upgrade with boiler replacement	0.50	15		2.45		4.32	1.26	120	10	29.1
Heating controls-extra	0.09	15		6.77		2.88	0.80	196	10.2	29.5
Fridge saver- Type schemes	0.10	10 to 12	0.4	0.5	0.72	0.72	0.29	176	17	0
Appliance replacement—higher efficiency models	0.60	10	0.4		1.44					
Applicane cold	0.88	12		0.22		2.52	1.08	29	0	0
Appliance wet	1.17	12		0.07		0.72	0.29	15	0	0
Appliance set top box	0.50	8		0.04		0.36	0.01	2	0	0
Compact fluorescent lamps										
CFL's (extra bulbs)	17.60	14	0.11	0.04	12.60	7.20	0.94	5	47.7	47.7
CFL's (new bulbs)	12.60	8	0.25	0.04		24.48	5.15	6	0	34.1
CFL's retail	9.75	16								
CFL's direct	32.64	16								
Hot water tank insulation										
Tank insulation- new	0.17	20	8.32	1.62	15.48	2.52	0.36	19	10.5	26.2
Tank insulation- top up	0.46	10	1.62							
Draughtproofing	0.31	20		2.66	5.04	4.68	0.72	139	10	28.7
Total					130	469	53			

Sources: DETR (2000, pp. 25–27), DEFRA (2004b), Carsten R. (pers. comm.)
Notes: The databases used for the UK originate from the documentation accompanying the Energy Efficiency Commitment (DEFRA, 2004b) and the costs are converted to € under the rate £/€ = 1.47. One important assumption is that the 2005–2008 EEC is discounted at 3.5%, as decided by HM Treasury in January 2003 in order to reflect prevailing circumstances rather than 6% as in 2002–2005. This differentiation favors the measures with longer life cycle (i.e. cavity wall insulation) (DEFRA, 2004a).

Table 4
Cost-effectiveness of previous energy policies in The Netherlands

Policy instrument	Primary energy saved (PJ)		Consumers cost (€/ tCO_2)	Social cost (€/t CO_2)	Targets (energy saving)
	1995	2002			
Energy performance standard	2	4	−210 to −6	51–121	15–20% relative to 1995
Energy performance advice	3	4	−238 to −155	45–117	2 Mt CO_2 (2010)
Energy premium scheme					
Environmental action plan	5	9	−53 to −5	36 to 69	8.9 Mt CO_2 (in the period 1991–2000)
Regulating energy tax	13	40			

Source: Joosen et al. (2004).

the suppliers and a regional factor coefficient. The WhC are delivered after the program has been carried out and after the realization of the energy savings, where they receive the cumulated value in WhC. An important factor of the French WhC is the demonstration of additionality of the energy saving measures. The total costs of the whole scheme are estimated to 154 million € (Pablo et al., 2004).

4. Towards a White Certificates scheme in The Netherlands

4.1. Background

In this section an attempt is made to sketch the contours of a possible WhC scheme in The Netherlands. More specifically, we assess the effectiveness and efficiency of the WhC in the household sector in The Netherlands. In 1990, households consumed around 25% and 12% for heating energy and electricity, respectively, of the total primary national energy use in The Netherlands (Vringer and Blok, 1995). Household primary energy use rose from 403 to 420 PJ in the period 1990–2002 (CBS/EnergieNed.), accounting for almost 32% of total primary energy use in The Netherlands (Joosen et al., 2004) and hence making them an important target for energy saving policy. The majority of the residential energy consumption is used for space heating and the rest for hot water, cooking, cooling and other electrical appliances (Joosen and Byers, 2001). There have been several policies, mainly subsidies and standards, in The Netherlands aiming at the improvement of energy efficiency in households (see Blok et al., 2002; Joosen et al., 2004; Boonekamp et al., 2004). The most important measures introduced so far are the Energy Premium Scheme, Energy Performance Standard (EPN), Energy Performance Advice (EPA), Regulating Energy Tax (REB), investment subsidies for solar water heaters, energy efficiency standards for new buildings, energy labeling of electric appliances (for more information, see Joosen et al., 2004). Indicators for the effectiveness and efficiency of these policies are presented in Table 4. From these figures we can conclude that these policies applied in The Netherlands are considered cost-effective. Nevertheless, further space for energy saving in the built environment is present and the WhC could act as an additional instrument to further reduce energy use in a cost-effective way.

4.2. Methodology

The basic concept of this paper is the understanding and estimation of the effects of a potential WhC scheme in The Netherlands. Initially, as a first step we identified the *projects/energy saving measures* for The Netherlands that could generate WhC and fulfill national or EU energy efficiency targets. These projects must be additional to a reference case, in order to be recognized as "eligible" for the generation of WhC.[15]

For the calculation of the impacts of a potential WhC scheme in The Netherlands the costs of these energy efficient technologies are estimated for their full life cycle, discounted with interest rates that progressively decrease over time. The lower the discount rate, the lower the barriers to the introduction of WhC. In the first phase, a discount rate of 30% per year has been assumed in order to depict the limited diffusion of the energy saving technologies due to market imperfections (Poortinga et al., 2003; Goett and Moss, 1988). The decreasing scale of the rate down to 5% (representing a social discount rate) represents the gradual overcoming of the market inefficiencies that obstruct the diffusion of the energy efficient technologies in households through the implementation of the WhC. A general discussion on the discount rates is presented in Box 1.

We studied the application of two different sets of measures for a period up to 2020. The measures were extracted from the ICARUS database that was developed for The Netherlands (Alsema and Nieuwlaar, 2001; Joosen and Byers, 2001). For all described measures it provides data on the achievable energy savings, costs and current penetration. In our calculations we distinguish a small

[15] The additionality tests should prove that the projects compatible with this scheme were carried out independently of other policies and measures, and these investments would have not taken place in the absence of financing from selling the WhC (Pablo et al., 2004).

Box 1
General discussion on the discount rates.

The choice of proper and representative discount rate for consumers has been extensively analyzed in existing papers (Lutzenhiser, 1992; Train, 1985). Nyboer and Bataille (2000) have conducted a literature overview of the consumers' purchase behavior concerning energy appliances. They dealt with the issue as to whether high discount rates for the consumers represent only market failures, or whether they represent the real costs of making an energy efficiency investment. Sanstad and Howarth (1994) present a similar survey, analyzing the theories around consumer rationality in energy efficiency choices. Other studies, like Ruderman et al. (1987) have even revealed that the consumers can use excessive rates (as high as 88% per year) when making energy related decisions. Hausman (1979) has found a discount rate from 89% progressively reducing to 5.1% following an inverse order of household income levels. The 30% rate chosen in our analysis is much higher than the social discount rate of 5% as observed in the EU (Farinelli et al., 2004). We argue that through the use of the WhC scheme, implemented parallel with well structured information-marketing campaigns and also with flexible financial mechanisms that permit easy access to credit, the discount rate will tend to decrease and reach the level of the social rate. This methodology was applied also in the calculations performed by the MARKAL model in the EU SAVE ''White and Green'' project (Farinelli et al., 2004) in order to depict the effects of the WhC in Italy and Western Europe.

package of measures and an extended package. The *small package* (see Table 5) only includes the standard technologies applied in the UK's EEC (2005–2008). These are around 30 measures, which could represent a simplified design of a WhC scheme for The Netherlands, especially in terms of monitoring and verification costs. In addition to the UK's EEC measures we have included behavioral measures, i.e. measures that aim at reducing the standby power consumption of domestic appliances, since low-income households can more easily implement (Poortinga et al., 2003). The *extended packages* comprises 140 measures, including the measures from the small package, which were also taken from the ICARUS database (Alsema and Nieuwlaar, 2001; Joosen and Byers, 2001). The scheme in this case is therefore more complex and technologies that are expensive are also taken into account.[16] Cost calculations in ICARUS-4 are based on the environmental cost method (VROM, 1998). They are performed based on the end-user approach, using end-user energy prices (taxes and VAT included) (Alsema and Nieuwlaar, 2001).

4.3. ICARUS adaptations

All the technologies are tested separately for older houses (before 1996) and for newer residences (after 1996). The number of the dwellings in The Netherlands is assumed to increase from 6.2 million in 1995 by an average 6% every 10 years, up to 7.8 million in 2020. In 2002, indicatively, out of 6.6 million dwellings, around 46% are tenants and almost 20% belong to households with

[16]However, the efficiency of the measures, translated in energy savings, is rather different between the countries and households, due to a number of factors. For instance, an energy efficient heating system can be more effective in a poorly insulated house than a well-insulated house (Poortinga et al., 2003).

Table 5
WhC measures for the case of The Netherlands (small package)

Cavity construction	Dwelling status	
	Before 1995	After 1995
Wall insulation		
Cavity construction	✓	✓
Internal/external	✓	✓
Upgrade to Rc 3, 3,5 and 5	✓	✓
Roof insulation		
Heated/unheated attic	✓	✓
Upgrade to Rc 2,5	✓	✓
Upgrade to Rc 3, 4 and 5	✓	✓
Floor insulation		
Upgrade to Rc 2,5	✓	✓
Upgrade to Rc 3, 3, 5 and 5	✓	✓
Window insulation		
Single to double glazing	✓	✓
Washing machine (technical pot. 2010/2020)	✓	✓
Dryer (technical pot. 2010/2020)	✓	✓
Dishwasher (technical pot. 2010/2020)	✓	✓
Refrigerator (technical pot. 2010/2020)	✓	✓
Deep Freeze (technical pot. 2010/2020)	✓	✓
Combi (technical pot. 2010/2020)	✓	✓
Washing machine based on space heating system	✓	✓
Hot fill washing machine (based on hot water system)	✓	✓
Dryer based on space heating system	✓	✓
Hot fill dishwasher (based on hot water system)	✓	✓
Heatpump dryer	✓	✓
Gas heated dryer	✓	✓
Compact fluorescent lamps	✓	✓
Reduce standby: brown appliances	✓	✓
Improve current brown appliances	✓	✓
Condensing boilers	✓	✓
Replace electric by gas boilers	✓	✓

Source: Alsema and Nieuwlaar (2001)—ICARUS-4 database.
Note: Rc is defined as Resilient Channel.

incomes below the social minimum and minimum salary (CBS, 2003).

An energy price scenario in the ICARUS model has been created for which the effects of WhC are tested. The energy prices for different energy types (coal, light fuel oil, gas and electricity) are based on the ''Global Competition Scenario'', published by ECN/RIVM (1998, 1999), with economic growth data originating from The Netherlands Bureau for Economic Policy Analysis (CPB, 1996). In order to simulate current energy prices, we have replaced some of the energy prices in ICARUS by data from OECD (2000) for the year 2000 and these are in accordance with the Dutch energy data from CBS. Power plants are assumed to have an average efficiency of 40% (NOVEM, 2002). Concerning the timeframe, the calculations have been performed until 2020 in 5-year periods.

4.4. Effectiveness and efficiency of the measures

The energy savings potential in the household sector can be presented by means of a so-called Conservation Supply Curve (CSC). The CSC plots the estimated specific costs of measures against the cumulated energy savings of each measure. If the specific costs of a measure are above zero they are not economically profitable and are rejected. Fig. 4 shows the CSC for the household sector in The Netherlands at a discount rate of 5%. The upper line in the graph is the CSC for the set with a small package of measures while the bottom line reflects the extended package of measures. The maximum technical energy saving potential of the technologies with a 30% discount rate is almost 300 PJ in the case of the small package and 400 PJ in the case of the extended package. In case the energy prices rise or discount rate decreases, the gap between the CSC and the zero-specific costs widens, thus making more technologies economically profitable.

As shown in Fig. 5, the technologies that are profitable for the small package of measures can generate from 54 PJ (30% discount rate) up to 180 PJ (5% discount rate) cumulative energy saved, an increase of 240%, as the WhC bundled with information campaigns is implemented

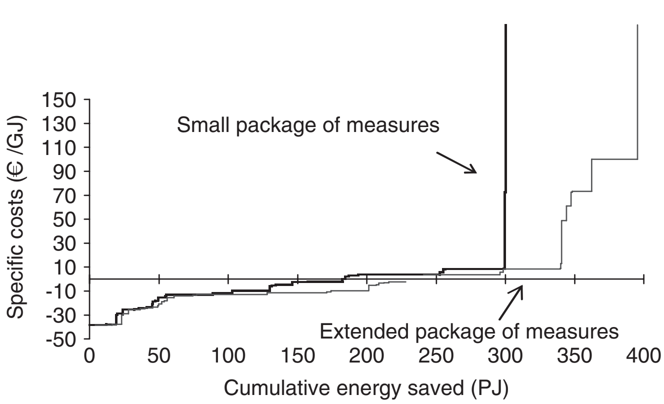

Fig. 4. Conservation supply curves for households for a discount rate of 5% (as of year 2020, based on ICARUS calculations).

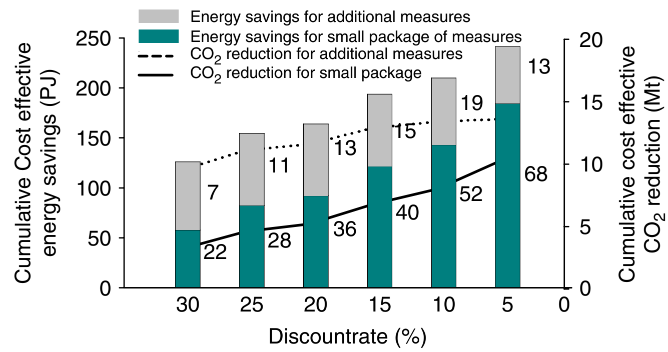

Fig. 5. Estimated primary energy savings and CO_2 emission reduction due to White Certificates for households in The Netherlands; cumulated results for the period 1995 to 2020 (each bar refers to the total period).

(based on the price scenarios of ECN/RIVM, 1998, 1999). These figures are significantly higher in the scenario with all measures, rising from 125 (30% discount rate) to 240 PJ (5% discount rate).

The discount rates in Fig. 5 decrease from left to right; since the market barriers are assumed to be overcome gradually, the x-axis can be interpreted as representative of time. A discount rate of 30% may represent the initial period (1995–2000) and 5% could be assumed for the final period of the scheme (2020). Each bar depicts the cost-effective primary energy savings and the number next to each bar depicts the number of energy efficient measures that are implemented.

The Dutch households' energy consumption can be reduced significantly by implementation of the WhC scheme. According to the ''global competition scenario'' (referred to earlier), the households' reference primary energy consumption (estimated based on the assumption of frozen efficiency) is increasing up to 704 PJ in 2020. In the case of the small package of measures, the cost-efficient technologies can reduce gradually the consumption from 667 to522 PJ. This corresponds to 8–26% energy savings compared to a frozen efficiency scenario and to a saving rate of nearly 1% p.a. For the extended package, the energy consumption can be reduced to 460 PJ in the last period, giving a saving rate of approximately 1.5% p.a. It must be kept in mind that these figures refer to the full effectiveness of the scheme, which may not be reached e.g. in the case of disinterest by consumers, for example if energy prices are very low.

CPB (2001) has calculated that such measures for energy efficiency improvement could provoke a significant rebound effect of 50% in the Dutch households. As discussed in Section 2.2, the estimates on rebound effects can vary significantly between countries and different energy efficiency improvement policies.

4.5. CO_2 emissions reduction

In Fig. 5 the cumulative energy savings of the households are translated to cumulative CO_2 emission reduction

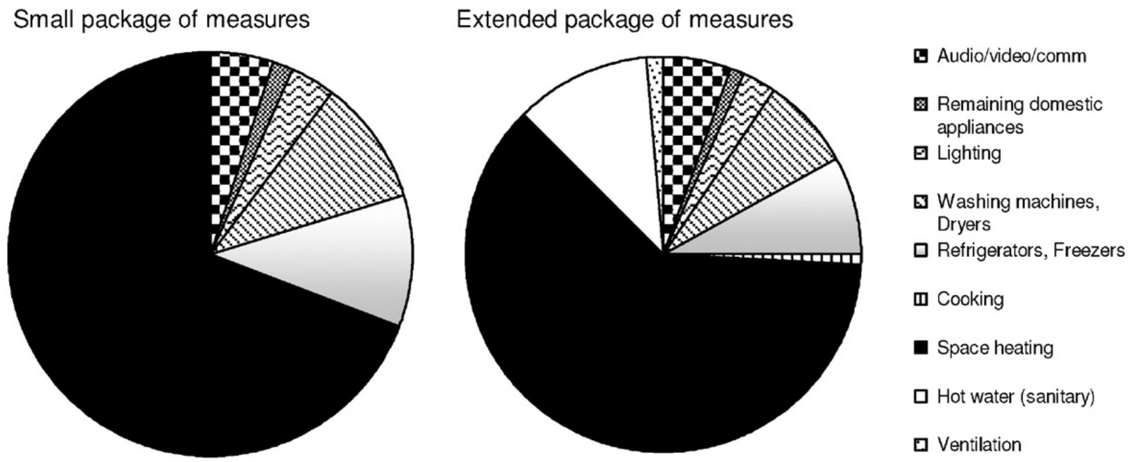

Fig. 6. Shares of cost-effective energy efficiency measures for the households with a 5% discount rate.

abated for the period 1995–2020 (see solid and broken line). For a discount rate of 5% these amount to 10.3 million t for the small package and 13.6 Mt for the extended package, contributing up to about 40% of the 6% reduction of emissions under the Kyoto Protocol (2008–2012) and the 10% in the post-Kyoto targets (2020).[17] Hence, WhC in The Netherlands seem to be able to contribute substantially to a reduction of CO_2 emissions in addition to the instruments already implemented. A cumulated amount of 3.2 Mt CO_2 can be abated by cost-effective measures in the initial period implemented of the WhC scheme in the case of the small package of measures and 9.5 Mt CO_2 with the extended package of measures. It should be noted that the total cumulative CO_2 reduction (1995–2002) achieved from all the existing policy instruments in the built environment was 2.4 Mt CO_2 (Joosen et al., 2004). This shows the effectiveness of the WhC scheme even under a simplified design.

4.6. *Diffusion of specific measures*

We now discuss the implementation of the various measures under various boundary conditions. In Fig. 6 we present the shares of the energy efficiency measures for the case of the small and extended package (left and right pie, respectively). These shares reflect the calculations with a discount rate of 5% and are based on the cost-effective energy saved from each category of measure. In both cases the major part of the savings originates from improved insulation. *Wall insulation* measures can be applied from the initial phase of the WhC, while *roof insulation* diffuses slowly and *floor insulation* becomes efficient only after the full implementation of the scheme in both packages. *Window insulation* is a cheap option in the initial phase, but it can be substituted by more effective measures in the longer term. Anyhow, good insulated windows (HR^{++}) have been installed in most Dutch dwellings as a consequence of previous policies (Joosen et al., 2004).

More efficient households' *appliances* become cost-effective after the successful introduction of the scheme (hence at a lower discount rates) and contribute substantially to overall energy savings. Nevertheless, in the case of the extended package of measures, the newest technologies of appliances diffuse even at high discount rates. Already today, many (A-label) energy white goods have achieved a high market penetration in The Netherlands as a consequence of the previous policies in the built environment (Joosen et al., 2004). Already, almost 20% of the household electricity consumption is caused by the use of appliances (EnergieNed, 2000).[18] A study in France (ECODROME, 1998) reveals that 40% of electricity savings can be achieved by replacing existing appliances with more efficient ones available in the market. *Gas heated dryers* and *energy efficient fans*, which are included only in the extended package, diffuse slowly at low discount rates. Relatively cheap measures, such as *CFLs*, *flow inhibitors*, *water saving showers* and *hot-fill washing machines* can be effective even at higher rates, while information measures are present in the whole lifetime of the scheme. A study conducted by ADEME (2001) revealed that the market penetration of CFLs has substituted almost 30% of the incandescent lamps in the EU market. In The Netherlands, 60% of the households in 1999 used at least one CFL, albeit only 2.4 out of a total of 36 lamps are CFLs in an average dwelling (OECD, 2003).

Boilers, condensing or heat pump, are not economically viable according to our calculations and are therefore not implemented, although they could be 25% more energy efficient than existing ones (Ziesing, 1999). An interesting

[17]The 40% contribution is a rough estimation, taking into account that The Netherlands need to reduce 12 Mt CO_2 in order to reach their designed targets for 2010 (Kuik et al., 2002).

[18]More specifically, in 2001, 55% of the Dutch households own dryers (increased at a rate of 34% from 1995), 72% deepfreezes (increase rate of 18%), 79% combi-oven (54%), 42% dishwashers (110%), 95% washing machines (3%) and 69% personal computers (77%) (CBS, 2003).

point from our calculations is that the efficient measures are applied mostly in the older dwellings (<1995), at a rate of 63 (first policy period) to 58% (last period) of the building stock during the policy timeframe. Furthermore, only the newest technologies on appliances (technical potential 2020) appear to be installed.

4.7. Cost-effectiveness of the WhC

Fig. 7 shows the estimated cumulative total net savings of the scheme from the cost-effective measures of the small package and of the extended package.[19] In the case of the small package of measures, the cumulative net savings for the period 1995–2020 amount from 1000 up to 3240 M€, while in the extended package, the total cumulative net savings rise up to 4550 M€, at a discount rate of 5%. On the other hand, taking into account the CO_2 abatement possibilities, since the marginal abatement costs for both packages of measures are similar, they are comparable in cost-effectiveness and promising in a WhC scheme for the Dutch economy.

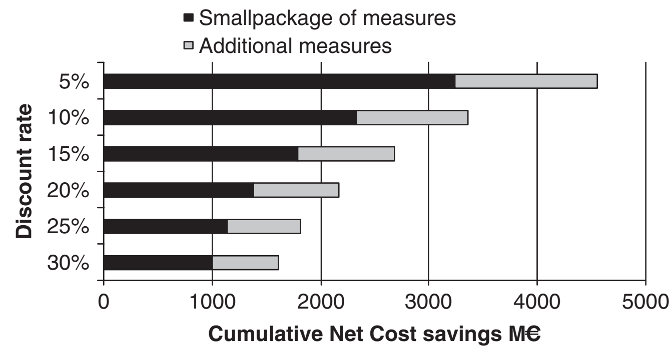

Fig. 7. Cost savings of a WhC scheme.

4.8. Discussion of the results

The results from the calculations reveal that the WhC in The Netherlands could be a useful energy policy instrument. However, these results can be subject to discussion, since they are based on some parameters and assumptions that have been established in the analysis. An important assumption made in this study is that of a decrease of discount rates. This decrease in discount rates represents the fact that market barriers are overcome over time through the use of WhC, which is partly a consequence of consumers becoming more economically rational in their decision making after becoming acquainted with the WhC. It would also have been possible to choose discount rates that are constant over time or discount rates that differ per measure. The method of decreasing discount rates was preferred since it can address the uncertainties over time for the overall consumer's behavior on energy efficiency investments and shows the effect of a successful policy. If the WhC System is coupled to well-targeted and diffused information campaigns and to simplified and publicly guaranteed access to credit (and/or to other measures), the apparent discount rate should indeed decrease (Farinelli et al., 2005). Furthermore, the market diffusion of the new energy saving technologies in the course of time is directly linked to the increase of net savings (both in monetary and physical terms) for the consumers.

Another strong assumption in the ICARUS database is that all the specific technologies are applied to *all* dwellings, depending on the penetration rate of each technology, which tends to lead to an overestimation of the benefits. On the other hand, practically all households are connected to the power and to the gas grid; the share of households that is excluded should therefore be very limited.

Another issue, as explained in the previous sections, which is crucial in a WhC scheme, is additionality. Additionality refers mainly to the prevention of free riders, i.e. the avoidance of measures which would have been taken also without the use of WhC scheme. In our calculations, this parameter cannot be taken into account for the long period. A factor that is not dealt with in this paper is the magnitude of the administrative and transaction costs in a WhC scheme. In the absence of studies for this measure, anecdotal estimates show that depending on the complexity of the scheme, the administrative costs can rise substantially mainly in the areas of monitoring, verification and enforcement of energy savings (Farinelli et al., 2005; Langniss and Praetorius, 2006).

Finally, as stated in the theoretical analysis, empirical studies have revealed that the decrease of the price of the technologies is not the sole parameter that determines the market diffusion. Income effects and price elasticity of energy services have been estimated to dominate in many cases in consumers' choices for energy saving measures.[20] Moreover, the split of the cost burden between the consumers and suppliers/distributors contribution can alter the results. However, in this study it was not intended to analyze in depth the consumer behavior, and therefore these aspects have been considered as given in the analysis of the effects of the WhC.

5. Conclusions

In this paper we have analyzed the mechanisms of a WhC scheme as an innovative policy instrument for energy

[19]The net savings are calculated as the difference of the total investment (fixed) plus operational/maintenance (variable) costs minus the cost savings (primary energy savings multiplied with the energy price). The symbols *i* refer to the individual measures, which are implemented in *j* time period. $\sum_{i,j} NS = \sum_{i,j} FCi + \sum_{i,j} VCi - \sum_{i,j} CSi$.

[20]In The Netherlands, De Groot et al. (1998) have calculated that for the households, the short run elasticity for electricity varies from 0 to −0.25 and for the natural gas from −0.05 to −0.15. In the long run, the price elasticities for electricity range from −0.30 to −0.45, for fuel from −0.20 to −0.30 and for natural gas from −0.10 to −0.60. Similar studies from NEMO (New Energy Model) reveal similar prices for The Netherlands (Koopmans, 1997; Koopmans and Te Velde, 2001).

efficiency improvement. Our main interest was the final consumers that are the recipients of energy services from the energy suppliers and distributors. The basic idea underlying this policy instrument is to set specific energy saving targets for energy suppliers/distributors that must be fulfilled in a specific time frame. The suppliers carry out energy efficiency projects for their consumers in order to achieve these targets. After the implementation of these projects they generate and receive WhC, in return for their realized energy savings. Such certificates can be exchanged and traded on the market.

Through the analysis of the energy consumer's behavior, we conclude that the major benefit of such a scheme is that it helps to overcome the "efficiency gap", i.e. the unwillingness of the consumers to purchase energy efficiency goods even though they are cost-effective and can generate energy savings. According to this analysis, the substitution effect caused by the relative change in price of the energy efficient goods seems to be outweighed by the income effect, i.e. higher consumption due to larger income overcompensates the positive effect of decreasing prices of energy efficient goods, despite the fact that both are considered normal goods. This finding underlines the need for policies and measures promoting energy efficiency.

Based on the current experiences acquired so far from WhC schemes in Europe, we studied two packages of technologies (measures) that could be used in a possible scheme in The Netherlands. Focusing on Dutch households, although this scheme can be applied to all non-energy-intensive sectors of the economy, we examined the overall effects of a possible scheme, without taking into account policy implementation and other administrative costs.

Based on the findings for the two packages of measures we conclude that this scheme has the potential to achieve high effectiveness in terms of energy savings and efficiency. The maximum economically viable cumulated primary energy savings for the period 1995 to 2020 can rise up to 240 PJ. The primary energy consumption of the Dutch households after the implementation of the WhC can be reduced by 26% (in 2020), compared to a frozen efficiency scenario. These savings stem from the use of new technologies that can be diffused in the market through the application of the scheme. The net cost savings in the last phase of the WhC scheme are three times higher than the initial phase of the scheme. Based on these findings we conclude that WhC are a policy instrument that could be useful for the design of future energy policy in parallel with the existing instruments and policies already applied in The Netherlands.

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Appendix A. Italian WhC measures

Replacement of incandescent lamps with CFLs
Replacement of electric hot-water heaters with gas heaters
Installation of new high-efficiency gas boilers
Replacement of gas heaters for hot water with more efficient gas heaters
Replacement of single-glazing window panes with double glazing
Increased thermal insulation of external walls of buildings
Installation of photovoltaic systems with peak power below 20 kW
Installation of solar heaters for sanitary hot water production.
Re-phasing of electrical lines in industrial plants supplied at high voltage
Installation of air operated, electric heat pumps in new or re-structured buildings replacing gas boilers
Co-generation plants with unit power (per module) greater than 0.5 MW
Medium-low power co-generation plants
Installation of electronic frequency-regulation systems in electric motors
Energy recuperation from the de-compression of natural gas
Installation of higher-efficiency motors and mechanisms for mechanical power transmission
Replacement of refrigerators, freezers, combined fridge-freezers, laundry machines, dishwashers with similar products having higher efficiency
Low flux showers
Aerated jet breakers for water taps.

Source: Oikonomou (2004), Gracceva and Contaldi (2004).

		Primary	Final
Energy coversion factors	For electricity	1 toe =	4.545 kWh_e
	For heat	1 toe =	11.628 kWh_t
Energy rates (average 2003, tax included)	Electricity residential	1 toe =	900 €
	Nat. Gas residential	1 toe =	801 €
	Nat. Gas non-residential:	1 toe =	435 €

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