The End of Energy Efficiency Improvements = The Start of Energy Savings?!

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ABSTRACT

While increased energy efficiency of household appliances has reduced energy consumption to levels below a business as usual scenario, it has not resulted in decreased household electricity consumption. Current appliance policies are based on improving the energy efficiency of selected appliances and these alone will not achieve the targets that have been agreed under the Kyoto protocol. Furthermore, some appliance trends worsen the problems for current policies. For white goods for instance, energy efficiency improvements are slowing due to technical limits, whereas the increasing number and the changing identity of appliances make establishing policies more difficult.

The concept of sustainable energy balance is presented as an alternative policy framework to make the change from appliance efficiency alone to a set of integrated policies that result in the decrease of household CO_2 emissions. In the sustainable energy balance scenario, energy consumption equals sustainable production of energy. The CO_2 target for households is, like the targets for other sectors, derived from higher level policy goals. Financial instruments (e.g. an energy tax) and information instruments (e.g. feedback on household electricity consumption) are suggested as useful instruments at a household level to achieve household targets. Appliance efficiency policies will continue to play an important role in this broader policy goal, as will policies to increase the sustainable production of energy.

Introducing the Problem: Increasing Household Electricity Consumption

Introduction

Increasing energy efficiency has been the central paradigm of energy policy for many years. Energy policies such as energy labeling and energy efficiency standards for household appliances have undoubtedly been successful in increasing energy efficiency. However, since climate change has become a major issue, targets for stabilization and even reduction of greenhouse gasses have been established. The consequence of these targets is that they establish an absolute limit to emissions for developed countries in the first instance. With respect to electricity consumption, there are two ways to achieve such CO_2 targets: energy savings, i.e. a decrease in electricity consumption (through either energy efficiency or a reduction in energy services), and the reduction of CO_2 emissions during the production of electricity.

The context of this paper, sketched briefly above, can be summarized into the following key questions:

- Is the current policy of increasing energy efficiency enough to achieve Kyoto targets, i.e. to decrease CO_2 emissions?
- If not, how can energy savings be achieved, i.e. how can a comprehensive set of policies be built?

However, as important as these questions are, this paper only focuses on the magnitude of the contribution that has been and is likely to be made by energy efficiency towards these goals.

To illustrate these issues, household electricity consumption has been used as an example. Several reasons can be given for selecting this sector. Households, equipped with their barrage of appliances and equipment, account for 30% of all electricity generated and used in OECD countries, producing 12% of all energy-related CO_2 emissions (IEA 2003). Secondly, household appliances have been the target of a large variety of energy efficiency policies for many years and they should exhibit the impact that energy efficiency improvements can contribute; see (IEA 2000). Thirdly, households are considered by some to be a difficult target regarding climate change program measures.

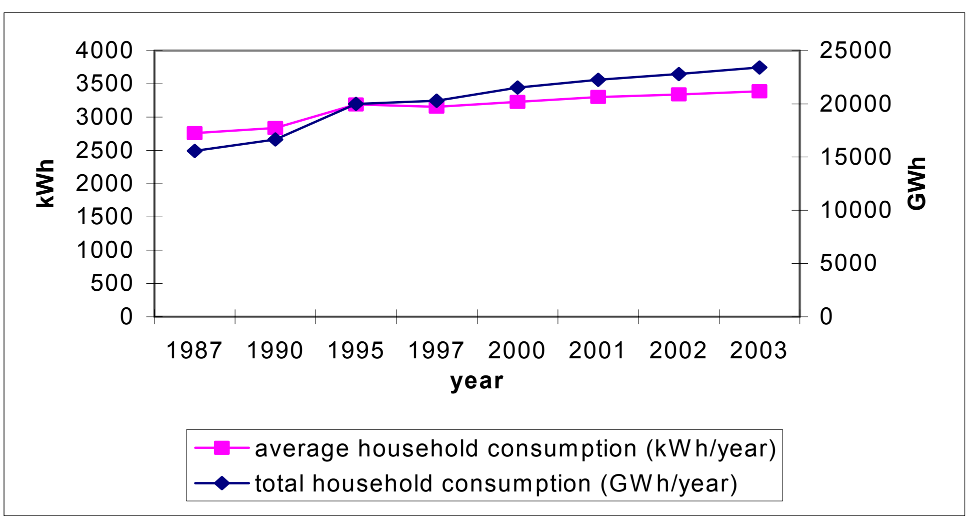
Furthermore, this paper draws heavily on experiences from Europe, and the Netherlands in particular, although indications exists that the same trends are relevant in other parts of the world; see (Meier 2003). This paper does not purport to give a comprehensive international overview on household electricity consumption, nor a final answer to the questions asked. The intent is to initiate discussion on whether energy efficiency is sufficient on its own, and if not, what additional measures may need to be considered.

The Problem: Increasing Household Electricity Consumption

Household electricity consumption has increased, and is expected to increase further, despite higher efficiency levels for many products. Even in the Least Life-Cycle Cost Scenario, electricity consumption of appliances in 2030 is expected to be on the same level as in 2005, despite 33% savings relative to the current policy scenario which includes MEPS and labeling for appliances (IEA 2003, 14).

Figure 1 shows historical data for household electricity consumption in the Netherlands. Unfortunately, the Netherlands provides an excellent example of the statement that household electricity consumption increased despite higher energy efficiency levels in a wide range of appliances. For example, the Netherlands has the highest penetration of "A" rated white goods under the EU energy labeling scheme (where A is the most efficient and G is the least efficient), (Soregaroli 2003) and despite this, other factors appear to have lead to increased total electricity consumption.

Figure 1. Average and Total Household Electricity Consumption for the Netherlands



Source: (BEK 2000, 2003)

Appliance Trends: Why Current Appliance Policies Are Not Sufficient

Trends in a number of factors have a direct effect on energy consumption of households and complicates policy making. These factors include the ownership of appliances, number of households, energy efficiency of appliances, appliance size, frequency or duration of use and identity. Trends in each of these aspects are examined to illustrate current trends and the impact that they have on energy consumption.

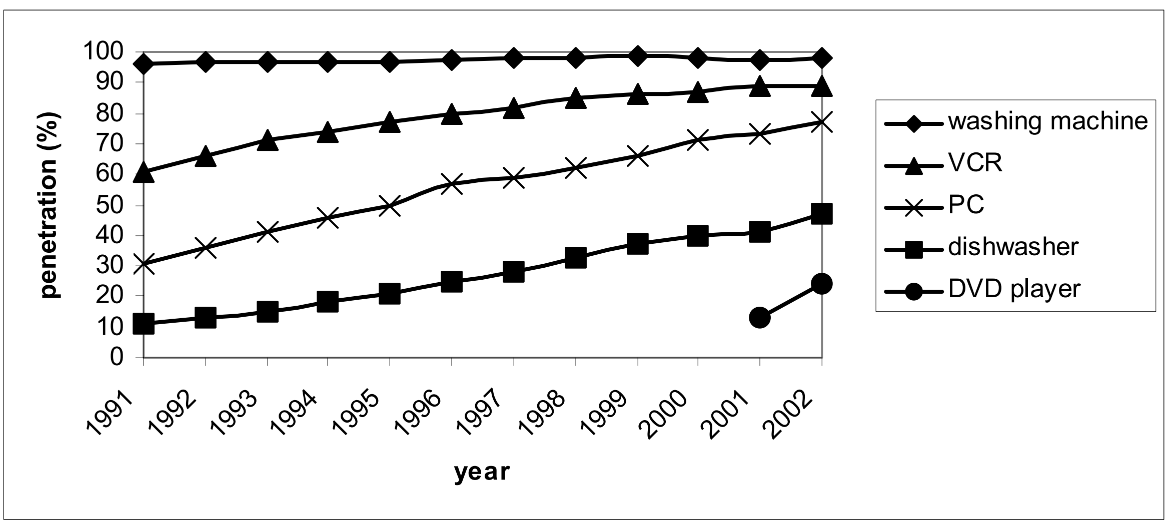
Number of Households and Ownership of Appliances

In most countries population is growing, and the number of households is increasing even faster due to a reduction in average size of households.

For some products the ownership is saturated and stable (e.g. refrigerators, clothes washers) meaning that the growth in the number of these products mostly comes from an increase in the number of households. For other products ownership is growing slowly, but steadily. Whilst for many new products like DVDs, the growth in ownership is extremely fast. The total stock of appliances (which is a function of household numbers and ownership) has a direct impact on energy consumption.

Drivers for increasing ownership are increasing income of households, lower real-term prices of appliances and individualization of appliances. Individualization is the effect whereby appliances that used to be shared by household members are now becoming personal appliances. This trend is especially visible in the areas of home entertainment and communication where in some households every person has their own TV, VCR, stereo, etc. Furthermore, as a result of these driving forces, new appliances are continuously being introduced on the market and in some areas this can be seen as a "proliferation" of new uses. Although there are occasional examples where a new type of appliances replaces an outdate technology type (e.g. the DVD player can replace CD player, DVD recorder can replace VCR and CD player), in most cases new appliances are additional to the existing suite of products. Figure 2 illustrates some of the trends based on figures on household appliance penetration (percentage of households that owns one or more appliances of a certain type) in the Netherlands.

Figure 2. Household Penetration Trends for Several Appliances in the Netherlands



Source: (BEK 2000, 2003)

Energy Efficiency

The concept of energy efficiency plays an important role in energy policy. With respect to appliances, energy efficiency can be defined as the ratio of useful output (energy service) by an appliance to the energy input needed to deliver these services. For example, energy efficiency for washing machines is expressed by the amount of textile cleaned (kg wash load) per unit of energy (kWh) used.

Regarding the concept of energy efficiency, two important observations can be made. Firstly, energy efficiency can not be determined without specifying the quality of the output (energy service) that has to be delivered. In some cases specification of the energy service is difficult, e.g. for TVs where features like picture and sound quality play an important role but are somewhat subjective depending on the environment where the viewing takes place and the recipient. Secondly, the relationship between energy efficiency and energy consumption is influenced by the volume or amount of the output. So, if the energy efficiency increases, the energy consumption only decreases if the output is the same. In many cases increases in energy efficiency are associated with increases in energy service demand which negates some, or all, of the benefits of energy efficiency, the so-called rebound effect. A classic example is where household insulation is fitted to a poorly-insulated building shell; the occupants will often increase the heating comfort levels in the house (because it is now practical and economic to do so) so the energy consumption may appear unchanged even though the energy efficiency has increased (because the energy service being delivered has increased).

Development of energy efficiency. The history of energy efficiency policy for (household) appliances has been variable. Certainly, the efficiency of white goods (most notably cold and wet appliances) has improved in the past decade; see (Waide 2001). In Europe, several studies were carried out in order to progress the implementation of the European Commission framework directive on energy labeling (EU directive 92/75/EC) in the early 1990s. The goal of these studies was to, amongst others things, specify the energy saving potential and to provide suggestions for the class limits of the EU energy label (the technical definitions of the label grades A to G). The table below illustrates some of the findings of these studies and compares them to products on the market today. Consideration of these numbers raises the question: "Is this the end of energy efficiency improvements for white goods?" Within the current limits of known technology and energy service, it appears that energy efficiency improvements are likely to diminish significantly or even stop in the foreseeable future.

Table 1. Energy Efficiency Status in White Goods (EU)

Appliance	Source	Current best (2004)	Technical limit identified in 1990
Washing machine	(Novem 2001)	0.16 kWh/kg (on standard 60°C cotton program)	0.16 kWh/kg (on standard 60°C cotton program)
Dishwasher	(GEA II 1995)	EEI < 0.64 (A label) (on standard program)	EEI around 0.60 (on standard program)
Cold appliances	(Cold II 2000)	EEI around 30 % (A++ label)	EEI around 20 %

EEI: energy efficiency index; 1.00 or 100 % is average EU appliance efficiency in 1995 (GEA II 1995) Cold appliances include refrigerators, refrigerator-freezers and separate freezers.

For consumer electronics and IT equipment, such studies are rare and the picture is unclear. First of all the problem of defining energy efficiency for many of these product types is encountered (see above). In most cases this problem is solved by defining the output (services) to be the same for all appliances of a certain type and compare only the input power to provide this service. However this can be complex for digital devices that have many active modes and levels of services (e.g. computers which currently increase in computational power by an order of magnitude every few years). This is one of the reasons why measures have been restricted to the standby mode(s) for many of these product types, because a uniform service could be defined for this mode. Regarding standby, improvements have been achieved by a number of products, e.g. TVs, VCRs, PC, monitors (see table 2). However, for consumer electronics and IT equipment, efficiency improvements for single appliances are generally negated by the increase in the number of new types of appliances coming on the market. For some of these products, standby trends have in fact been deteriorating (e.g. reduced use of the off-mode for PCs and monitors), which has increased global interest in standby policies for many of these products.

Table 2. Energy Efficiency Developments Regarding Standby

			year					
Appliance	**Unit**	**source**	1995	1996	1997	1998	1999	2000
TV	standby power [W]	EICTA (2002)		6.18	5.43	4.4	3.98	3.77
VCR	standby power [W]	EICTA (2002)		6.64	6.27	5.94	4.9	3.87
PC	standby power [W]	Energy Star	30					15
monitor	standby power [W]	Energy Star	30			8		

Values for TV and VCR are EU sales weighted figures for appliances sold in that year. Best on the market is 0.1 W for TVs and about 3 W for VCRs since 1995. Values for PC and monitor are Energy Star criteria.

Use and Size

Use. The use (frequency, duration, control settings, etc.) also determines the energy consumption of most appliances; some small end uses with a monitoring type function (smoke alarms, security systems, answering machines etc.) and refrigerators and freezers (where consumer use patterns only have a small impact on total energy consumption) are probably the main exceptions here. It is important to remember that even the most inefficient appliances that are not used (and remain unplugged) do not consume energy. However, for several appliance types the usage is increasing: with the penetration of broadband access (at a flat rate for a permanent connection), leaving PCs on 24 hours per day is an increasing occurrence.

Furthermore, since the introduction of appliances with a standby mode, appliances are likely to be in this mode when they are not in use, i.e. many are not switched off (0 W) or cannot be switch off any longer like their predecessors without standby modes. In fact the number of products with an “off” switch is declining; see e.g. (NAEEP 2003).

Size. For a lot of products, e.g. refrigerators, freezers, TVs, size is an important feature. In general, the trend is towards larger appliances: e.g. larger refrigerators, larger TV screens. Although larger appliances in most cases are more efficient then smaller ones, i.e. use less kWh per liter of cooling space or per unit of screen size, their absolute energy consumption in many cases is higher.

Identity

The identity of appliances is determined by their primary use and functionality. Why treat identity of appliances as a separate trend? Appliances are used by households to provide services: entertainment, clean washing, etc. So, with the previous sections on ownership, efficiency and use, the identity is largely covered for most product types.

However, this is changing. Appliances used to be clearly dedicated to one service: a refrigerator to keep food fresh, a television to provide visual entertainment. With a trend towards more complex and versatile appliances, two interconnected trends can be observed:

- Increasing functionality. Appliances are starting to offer several different services, e.g. a refrigerator with an internet screen or a monitor that can be used as a TV, a computer that can be used as a TV, DVD player or a CD player. Other "smart" or fuzzy logic appliances do not have a fixed program but can adapt their activities to the input, e.g. the more dirt there is on the plates in the dishwasher, the more intensive and/or longer the program. Furthermore, appliances can be reprogrammed after purchase and installation through software downloads via the internet.
- Increasing connectivity. Products become connected with each other and with the outside world so that remote control and programming becomes possible. If nothing else this could have significant implications for standby power requirements.

Consequences of Appliance Trends for Policies

Energy efficiency policies for appliances, e.g. labeling or minimum efficiency standards, require, as a minimum, the following:

a) a precise definition of the appliance category to which the policy is targeted.
b) a standard to measure energy consumption and in some cases performance; in general this means that energy and performance are measured under one (sometimes more) set of standard conditions.

It is on these requirements that the impacts of the increasing number of appliances and the changing identity of appliances will be discussed.

Increasing number of appliances. New appliance types and changing and smart appliances require new or revised test procedures. This is an increasing burden for standardization bodies. Furthermore, with an increasing number of appliances, the energy consumption of households is spread across more appliances types. To control energy consumption at an appliance level, more policy measures are needed. However, each of these program measures are likely to deliver lower levels of energy savings than previous policies for "traditional" appliances did.

Changing identity of appliances also poses a serious problem for policy making. First of all it is more difficult to precisely define the appliance category. Is a monitor that can also be used as a TV to be treated as a monitor, as a TV or as both? Can a refrigerator with an internet terminal be treated as a "normal" cold appliance? What to do with VCRs with surround sound system? In general this results in more product categories and thus more complex standards and energy policies.

Secondly, what should standard conditions be under which energy consumption or performance is to be measured? Already on several white goods a multitude of programs can be chosen by the user, e.g. 60°C cotton, 40°C easy care for washing machines. To develop affordable test methods, a choice has to be made, but which? Ideally, test procedures should be generic enough to determine an appliance's performance across all major programs and operating modes – this would then enable a more accurate estimate to be made of in use energy consumption from standard laboratory test data. Estimating in-use energy can be complex and may require modeling or simulation in some cases.

A simple calculation example illustrates the effect of the trends on energy consumption. Consider: household numbers increase by 2% per year, energy efficiency of appliances increases by 1.5% per year, size or use increases by 1% per year and other trends are steady. In this case there is net energy growth of 1.5% per year despite a significant and persistent increase in energy efficiency. Clearly with the proliferation of end uses this picture is more complicated.

Appliance Policies: Some General Characteristics and Defects

Experience has shown that market forces alone are not sufficient to achieve efficiency improvements and/or energy savings. Therefore numerous policies have been designed in order to achieve the desired goals; see e.g. (IEA 2000). This section briefly investigates some general aspects of appliance policy programs and indicates some problems – additional to those identified in the foregoing section – with respect to achieving climate change goals that result with the current types of policies.

In setting up an energy policy program for appliances, the following general approach is usually used; see for example (IEA 2000, 29-30):

1. Preliminary Assessment
2. Authorisation and Program Design Procedures
3. Priority Refinement – Products and Instruments
4. Design – Technical Parameters and Compliance Deadlines
5. Design – Testing Procedures
6. Design – Administrative Rules and Conformity Assessment
7. Monitoring, Evaluation and Reporting

This approach can be summarized as sorting *products* according to their energy saving potential or, in more general terms, according to their potential to contribute to an overall goal (e.g. CO_2 emission reduction). Since policy capacity is limited, policies will often only be implemented for the top five or top ten products on the list. In this way, it can be understood why it took relatively long for standby consumption to be considered as an "energy problem". Per appliance, standby consumption - and therefore the savings potential - is (very) low, a few (1 to 10) Watts. So, even if these appliances in this mode would appear on the preliminary list of items for consideration, they would never be in the top 10 priority when considered at the appliance level. Only when standby as an aggregated end-use across appliances was identified, that it was ranked among the highest remaining energy saving potential products in the residential sector.

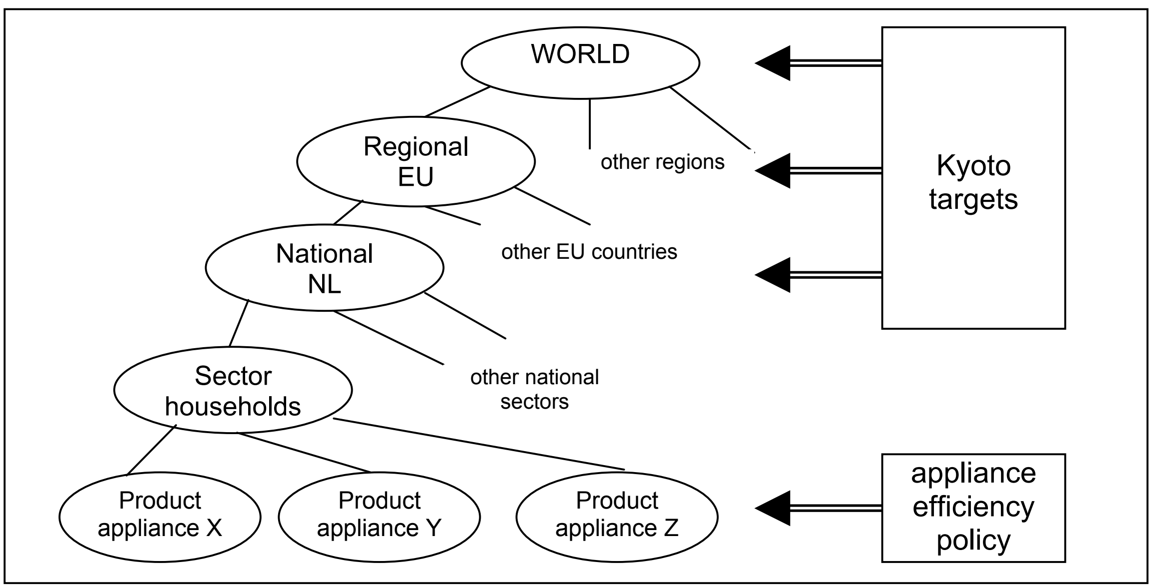
The mechanism also explains why policies have been targeted at large appliances, because in general these appliances demonstrate a large saving potential per appliance. Thus, most countries have targeted the same products for their policies (refrigerators, air conditioners). On the one hand this was good, because it provided a strong signal to manufacturers, but on the other hand it left products outside the priority list largely untouched.

Also, applying policy instruments at the appliance level leaves the following gaps:

a) it does not include appliances that are not targeted (i.e. those appliances that could not be defined when the policy process started); and
b) even where an appliance is targeted, behavioral aspects are often not regulated (for good reasons, because this is usually impractical).

Finally, current appliance policy instruments in their current form will not, by themselves, enable the targets that have arisen from the Kyoto protocol to be met. These targets require limits on absolute values of CO_2 emissions, whereas appliance policy instruments only have a relative (efficiency) effect. Figure 3 illustrates this point. Global emission targets (Kyoto targets) are translated into regional and national targets (e.g. EU, the Netherlands). The appliance energy policies however only target the efficiency of a limited number of individual appliances.

Figure 3. Relation Between Targets and Appliance Policies



Two general explanations can be provided to the question as to why increasing energy efficiency has been a policy target rather than lowering energy consumption.

In general policy makers tend to focus on the energy consumption per appliance rather than total energy consumption for a particular product. They have a good reason to do so, because increasingly, policy makers are evaluated on the effect of their policies. A guiding principle in this evaluation is that one can not be held responsible for factors that one can not control (e.g. the number of products). Since most countries do no want to pose restrictions on the number of households nor on the number of appliances in those households, these trends are factored out when examining efficiency trends and savings. The savings are calculated relative to a baseline that includes a growing number of households and – in some cases – an increasing number of appliances. The conclusion of this type of analysis is typically that energy has been saved relative to the base case due to energy efficiency improvements. While this is true, invariably the total energy consumption will continue to grow in absolute terms due to increases in ownership, number of households and possibly usage. Although there may in fact be savings accruing from the program, it does not solve the climate change problem. Climate change is completely indifferent to the source of CO_2 emissions – whether this is the result of an increasing number of household or an increasing use of appliances – it is the absolute level of CO_2 emissions that is important. The argument that the situation would be worse, if there had not been any energy efficiency policies is true, but not relevant to the fact that current policies on household appliances are simply not sufficiently effective to tackle the climate change problem on their own.

Secondly a large gap exists between what people think is good for society and what they would like to contribute themselves. So, while fighting climate change is a noble goal for society, using your car less as a contribution to this goal is not something that many households actually do, even if they know they contribute to a noble goal by doing so. The same holds for decreasing electricity use. This also explains why the concept of efficiency is so popular, because it seems that you can still drive a car (or use electricity) and at the same time contribute to CO_2 reduction. However, it is illustrated above that the "efficiency trick" alone does not work. Of course it does not follow that there is no need for energy efficiency: increasing efficiency certainly contributes towards the sustainable energy goal, but it is not an end in itself or the only policy that is required.

The Sustainable Energy Balance

Introduction

In the previous sections firstly the problem was identified that increased energy efficiency of household appliances has not decreased household electricity consumption. Furthermore, some appliance trends worsen the problems for current policies. For white goods, energy efficiency improvements are likely to diminish in the future, whereas the increasing number of appliances, the increasing level of service, and the changing identity of appliances make establishing policies for other appliances more difficult. Furthermore some problems were discussed related to current appliance policies: these are based on improving the energy efficiency of selected appliances and are not entirely compatible with the targets that have arisen from the Kyoto protocol. In this section an approach is suggested to bridge the gap between higher level (top-down) Kyoto targets and the (bottom-up) appliance level policy.

An Alternative Policy Framework: The Sustainable Energy Balance

The framework for an alternative solution consists of two concepts:

1. The sustainable energy balance where energy consumption equals sustainable production of energy.

2. Matching the targets for CO_2 reduction on world and regional/national level with the household level, in other words to control the energy consumption of households instead of the efficiency of appliances.

The two concepts are related. Although some consumers might reduce their energy consumption according to a general maxim to be economic with resources, most people would need more coercion. An equitable level is provided by translating the national CO_2 targets (expressed in absolute levels) into a target for households (and of course other sectors). As such, household energy targets are derived from higher level goals and *not* from the savings potential of individual appliances. Such a target is independent of how many appliances people have.

The concept of the sustainable energy balance introduces an additional degree of freedom to satisfy environmental targets: as long as sustainable production can match energy consumption, there is no need to cut consumption. Since all (household) energy consumption should be matched by sustainable production, achieving the sustainable energy balance is a long term goal. However, depending on circumstances or policy preferences, emphasis could be placed on either decreasing energy consumption or increasing sustainable production, or both. Several countries have already issued long term (2050) targets for significant reductions in CO_2 emissions, e.g. 60% the UK Energy White Paper (DTI 2003).

The concept requires control of the energy consumption at the household level; how can this be done? By using policy instruments at the household level. These should ensure that not only the technical potential (efficiency) but also the economic and social potential (ownership and usage) is realized. Thus the gap between the absolute values of the Kyoto targets and the policies on the appliance level (see figure 2) is bridged. In the rest of this section possible instruments are discussed using a well known categorization: financial, information and legislative instruments.

Financial instruments. A well-known financial instrument is an energy tax. The less energy people use, the less energy tax they pay. Higher energy prices also reduce the pay-back period of investments in energy saving products or in energy production by households (e.g. photovoltaics). However, experiences in the Netherlands show that an energy tax alone does not solve the problem. In the period 1996-2002, the energy tax for households in the Netherlands was increased stepwise from 1.59 Eurocent per kWh to 7.15 Eurocent per kWh. As figure 1 shows the average electricity consumption of households still increased over this period. However, it is important to note that consumer behavior in terms of household energy and transport is extremely inelastic, and tax increases have to be very large to stimulate significant changes by consumers.

One important consideration with regard to energy taxes is how these are spent. Some economists argue that high taxes on emissions or energy provide the opportunity to reduce taxation burden in other areas. However, from a policy perspective, it makes sense to quarantine these funds for use in energy sustainable investments. These could take the form of contracted energy efficiency program delivery (above and beyond regulatory programs) and stimulation of renewable and other sustainable energy supplies.

The principle of the sustainable energy balance provides a guideline for the level of the energy tax, if this tax is used for (the stimulation of) building sustainable production capacity. In combination, the tax level for households that buy sustainable electricity could be set to zero.

Information instruments. Providing feedback on the electricity consumption of households can result in energy savings, see e.g. (Darby 2000). Currently, households are generally informed about their electricity consumption when the bill arrives. The frequency of billing varies between countries, e.g. quarterly in Norway and yearly in the Netherlands. In most cases the frequency is far too low to be effective as feedback and consumers often have no idea about what end uses contribute significantly to their energy bill in any case. Modern equipment (e.g. digital electricity meters that are directly connected to the database of the electricity provider) solves many of the problems that were connected with feedback in the past. The most important function of feedback is to trigger the attention of the household. If households pay attention to their electricity consumption, chances increase that they take action to reduce consumption. Frequent feedback, e.g. at least monthly but more frequent if required, provides a strong instrument to reinforce the changes. Although, in view of the longer term CO_2 emission targets, the impact of information instruments alone is relatively small, the principle of feedback ties households into solutions to the climate change problem and provides insights into their contribution.

Legislative instruments. (Tradable) quotas, in terms of restricting the amount of electricity per year that a household can use, are amongst the most stringent policy instruments. For this paper, they are considered a last resort, for use when other instruments have failed.

Policies at the appliance level are not irrelevant in the goal of a sustainable energy balance, but these need to be put into context as one of many contributions towards a proper integrated framework. Enabling households to buy efficient appliances, e.g. by stimulating the development of energy efficient appliances and providing information on the energy consumption and efficiency of appliances is an important requirement. This implies that labeling and other appliance information systems, minimum efficiency standards and voluntary agreements are still important policy tools. They also provide a signaling function from governments and industry to households. The concept of sustainable energy balance provides the additional framework to tie these means to the end of achieving a sustainable society.

Given the magnitude of the reductions in emissions that need to be made to achieve longer term sustainable energy targets, it is clear from the analysis in this paper that a large increase in sustainable energy source supplies (such as renewables) will need to developed as part of an integrated policy mix.

Conclusions

This paper illustrated that, despite large efficiency improvements for household appliances, household electricity consumption is still increasing. This poses a serious threat for achieving climate change goals such as those set for Kyoto targets.

The increased number of households, increased electricity consumption per household due to more appliances and the more frequent use of appliances in many cases has, and will, negate efficiency improvements achieved for single appliances. Furthermore, also some problems regarding appliance policies have been identified. With an increasing number of types of appliances, increasing efficiency policies for single appliances will deliver ever diminishing results. Up to now, appliance policies have only targeted appliances with a large technical savings potential, leaving untouched other appliances as well as the savings potential from changes in user behavior. Furthermore, policies that increase appliance efficiency, e.g. labeling, minimum efficiency standards, voluntary agreements, will ultimately not deliver the magnitude of greenhouse emission reductions that are needed to tackle the climate change problem.

The concept of sustainable energy balance was presented as an alternative policy framework to make a change from appliance efficiency to decrease of household CO_2 emission. In the sustainable energy balance energy consumption equals sustainable production of energy. The CO_2 target for households is, like the targets for other sectors, derived from higher level goals. Financial instruments (e.g. an energy tax) and information instruments (e.g. feedback on household electricity consumption) were suggested as useful instruments at a household level to achieve household targets. Appliance efficiency policies will continue to play an important role in this concept, as will policies to increase sustainable production of energy.

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