

Energy Efficient Appliances for Low-Income Households

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Abstract

The EU Directive on energy labelling of household appliances (Directive 92/75/EC) and its revision (Directive 2010/30/EU) are quite successful in helping households choose energy efficient products (http://www.measures-odyssee-mure.eu/public/mure_pdf/household/EU12.PDF) and in motivating the industry to invest in energy efficient product design. Purchasing energy efficient appliances is, however, dependent on financial capacity, as energy efficient appliances are still expensive. Low-income households very often use second-hand appliances which are old and less efficient which implies a high potential for energy savings. So, the above mentioned directive is only one factor in the expansion of the energy efficient appliance market, bringing the products into households.

Another factor is the introduction of policy programmes which support the investment in energy efficient appliances. In the context of a research project, the framework of conditions for such a programme for low-income households has been identified. First of all, it was examined which household appliance could most effectively be funded. It turned out that a replacement programme for refrigerators is the most promising. The supporting and inhibiting factors which influence the acceptance and the success of a replacement programme for refrigerators for low-income households were identified. For the analysis the existing international policy programmes which aimed at low-income households were screened and insights from group discussions with the target group and with stakeholders such as manufacturers and municipals were gained. We concluded that the funding of a replacement for an appliance alone does not guarantee the saving of energy; some boundary conditions also have to be considered.

Introduction

A low income in conjunction with the use of old and energy inefficient appliances can quickly lead to energy poverty, particularly if energy prices are high. A possibility of counteracting such a development is to help low-income households to invest in energy efficient appliances. This has the dual benefit of providing a financial saving for the household as well as a carbon reduction potential for the environment. Low-income households, however, have a double disadvantage in their lack of knowledge in saving energy in everyday life [1], and their financial constraints in converting energy saving tips into an investment of, for example, energy efficient appliances. Measures which consider both aspects could therefore help low-income households to reduce energy costs. There is a financial motive to save energy in order to save money.

The reduction of energy consumption, by the promotion of energy efficient appliances, is one aim of EU members at least since the energy efficient directive in 2007 was developed. The EU Directive 92/75/EC and its revision 2010/30/EU is only one measure applied in order to achieve this. Policy programmes and directives at the EU, and national levels support this. Examples include: Directive 2012/27/EU on the obligation to precisely label electric appliances (energy classes G-A⁺⁺⁺); Ecodesign directive 2009/125/EC which prescribes the eco-friendly and therefore for example energy efficient design for energy related products; and the European Ecolabel for appliances that have a reduced environmental impact throughout their life cycle, from the extraction of raw material through to production, use and disposal. There is also the well established Energy Star label set by the U.S. Environmental Protection Agency for appliances that meet strict energy efficiency criteria.

Table 1 displays the up-to-date maximum energy efficient classes of the EU label and the minimum requirements by the Ecodesign Directive for Appliances. The standby losses have also been successfully reduced through regulatory instruments (EG 1275/2008).

Table 1 Energy Efficiency Standards for Appliances

Appliance	Highest energy efficiency grades of the EU energy label	Minimum standards according to the ecodesign directive for energy related devices
Washing maschine	A+++	A+
Tumble dryer	A [A+++]	C
Dishwasher	A+++	A+
Cooling and Freezing Equipment (e.g. refrigerators)	A+++	A+
Electric Ovens	A	-
Vacuum cleaners	A	G
fume extraction hood	A	G
Lamps/light bulbs	A++	A/C
TVs	A+	D

Source: www.eu-label.de, www.eup-network.de, www.dena.de

Appliances in low-income households

In order to decide whether a certain appliance is to be funded, the energy efficiency potential of the appliance needs to be considered together with the ability to furnish low-income households with the appliance.

Electricity consumption of appliances

The comparison of electric appliances shows that refrigerators (with an integrated freezer) consume almost 25 % of the electricity in a household (Figure 1). They are the most energy intense appliance followed by TVs, cookers and dishwashers. The consumption of electricity largely depends on the length of time the appliance is in use. As refrigerators are continuously in use all day long, they consume a lot of energy and there is a high energy saving potential. A trend has, however, been observed for a longer daily use of TVs, computers and DVD-players [2] [3].

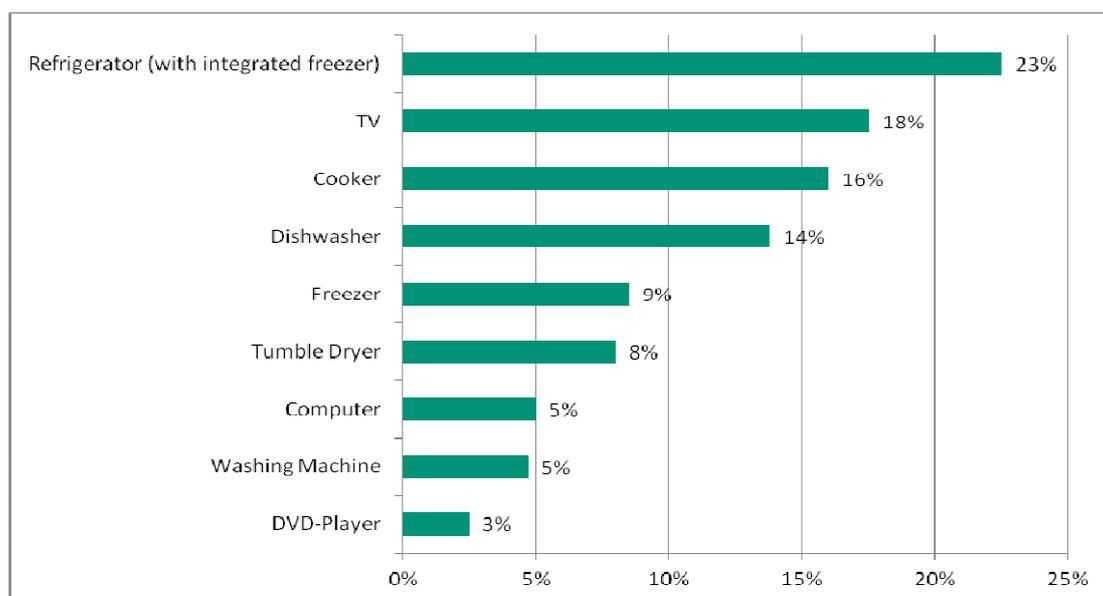


Figure 1 Electricity consumption of electric appliances in private households [4]

The absolute energy consumption of an appliance is influenced by further factors such as energy efficiency class, age of the appliance, service life, size, technical state of an appliance and consumer behaviour (e.g. refrigerator: temperature set, defrosting periods, time left open). A change in the behaviour of the consumer can lead to certain energy savings [5] [1].

Regarding service life, information and communication technologies (ICT) have an especially short life time (about 8 years compared to 15 years for white goods) because of the fast technological development and the consumers' ambition always to have the latest product. Furthermore, energy efficiency is not a significant purchase decision factor for these appliances. For example, for TVs the screen size is important and this is in turn correlated to electricity consumption [6:28]. PCs need much more energy than laptops [7] which could be a reason for funding laptops if most of the low-income households use a computer.

Penetration of appliances in low-income households

The following Figure 2 shows how many low-income households in Germany (so called "Hartz-IV households") utilise at least one of the appliances listed. Most of the households have acquired refrigerators and TVs as well as washing machines, but just 65 % use a computer. The study did not investigate the use of a cooker but this was analysed by Schlomann and colleagues [8:69] who found that 89 % of the German households have a cooker, which is usually electric [9:21]. The same study determined that some of the low-income households actually have more than one TV and more than one refrigerator [9].

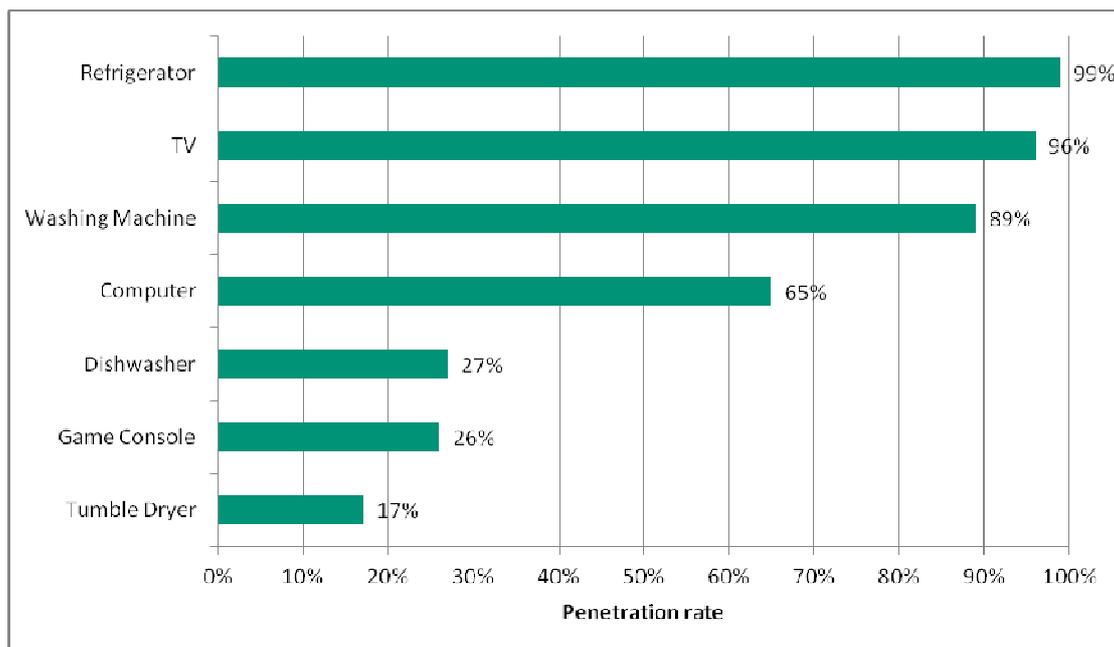


Figure 2 Furnishing of low-income households in Germany (Hartz-IV) with appliances [10]

Low investment energy saving devices could also contribute to energy saving: Switchable power strips are useful to reduce the stand-by losses of electricity, which are especially high for information and communication technologies (ICT). It is sometimes possible to use timers to switch off unused energy related appliances. Thermometers for the fridge can help to set a minimum temperature which is not too low and the use of electric kettles rather than boiling water on the cooker also saves energy. Such low investment measures have an immediate effect without changing behaviour on a big scale. The use of these small devices can also lead to an improved energy perception and could have an effect on other fields of consuming energy [11].

Refrigerators are most promising

As one could see above refrigerators have got a high electricity consumption and are widespread throughout low-income households. Additionally low-income households very often use second-hand appliances which are obsolete and not energy efficient. There is substantial potential for *saving energy* from changing refrigerators that are more than ten years old, with high energy consumption, to new energy efficient refrigerators (Figure 3).

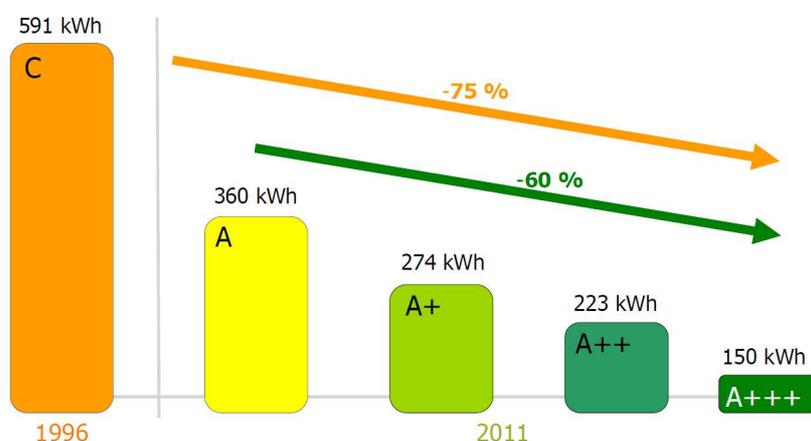


Figure 3 Comparison of Refrigerators with integrated freezers of different energy classes [12]

Some other factors besides energy saving confirm refrigerators as most promising for a policy programme for energy efficiency for low-income households. A high energy costs saving potential gives rise to a relatively low *amortisation rate* of the initial cost. Amortisation rate is displayed as:

$$\text{Amortisation rate} = \frac{\text{investment for new appliance}}{\text{annual energy savings (kWh)} * \text{energy costs per kWh}}$$

The older and the more energy intensive a refrigerator is and the lower the energy demand of its replacement, the shorter the amortisation rate. The best amortisation rate can be identified when a refrigerator and a freezer are substituted by a fridge-freezer: about 6 years amortisation rate without funding (Table 2).

Table 2 Amortisation rate of different scenarios

scenario	annual energy savings	energy costs	investment costs	amortisation rate
substitution of a ten year old fridge by a A++ fridge	200 kWh	25 ct/kWh	500 Euro	10 years
substitution of a ten year old fridge by a A++ fridge with 200 Euro subsidy	200 kWh	25 ct/kWh	500 Euro	6 years
substitution of a ten year old fridge and a ten year old freezer by a A++ fridge-freezer	300 kWh	25 ct/kWh	500 Euro	6 years

Source: Assumptions based on [13]

Another factor is the *ecological payback period* demonstrated by carrying out a life cycle assessment. The carbon emissions during the usage of refrigerators exceed the emissions during production [12] to make it worthwhile replacing a ten year old fridge with a new A⁺⁺ fridge after four years usage [14].

The *Product Carbon Footprint (PCF)* is the CO₂ balance of raw materials production, appliance production, trading, utilisation, transport and recycling. Bosch und Siemens Hausgeräte GmbH [12] report that 90% of the environmental effects of an appliance account for utilisation, 1% for transport and waste disposal each as well as 8% for production. Of course this depends on the appliance in consideration.

To account for *environmental costs* one has to look at saved emissions (CO₂ equivalents) by a refrigerator replacement. The assumption of 585,5 g CO₂/kWh (German energy mix 2005) and 70 €/t CO₂ environmental costs [15] [16] [17] as well as annual energy savings of 200 kWh per household leads to annual savings of CO₂ equivalents of 117 kg, and 8,19 € savings of environmental costs per household.

All in all the funding of the refrigerator, together with small energy saving devices such as switchable power strips, is the most promising way to support low-income households to save energy because of the following criteria:

- High penetration of refrigerators in low-income households
- High penetration of very old refrigerators in low-income households
- Refrigerators are not primarily a prestige object like a TV
- High energy saving potential of refrigerators
- Relatively low amortisation rate of refrigerators
- Quick payback of refrigerators regarding carbon emissions during production
- Substantial environmental cost savings

In order to ensure an energy-saving effect within a replacement program, the sponsor has to restrict the *size* and energy consumption of the new appliance. Moreover, the consumption patterns should be checked for rebound effects (i.e. proof of adequate disposal and no longer use of the old appliance). For a campaign, an additional information sheet regarding the correct temperature and the right placement of a fridge (e.g. not beside the cooker) is important.

International overview of policies

Valuable insights can be gained from existing international projects which address low-income households and energy efficiency. Examples from Australia, Austria and Germany are described below. Programmes in Denmark, Italy, Switzerland, Spain, Netherlands, USA, Canada and Cuba are also mentioned and used to discuss the drivers and barriers for a refrigerator replacement programme.

Australia: Energy Efficiency Program for Low-income Households (2003-2006)

Low-income households in South Australia receive free home energy checks which aim to examine household energy saving potentials in the following areas: water heaters, fridges and freezers, heaters and air-conditioners, washing machines, lights, cookers, and other appliances. An energy Advisor comes into the households and can help the householder to understand their energy bills and how to read their electricity meter. The participating households are also offered a free retrofit kit and may choose to receive a \$50 payment for retiring their second (or third) fridge or freezer. They could also be eligible for an interest free loan to purchase a new energy efficient appliance or other energy saving items. This offer is only available if significant energy savings, through replacement of a fridge or washing machine etc., are identified during the home energy check. A basic indicator of qualification for this scheme is the eligibility of at least one member of the household for a Health Care Card. This measure is organised by South Australian Government's Energy Efficiency Program for Low-Income Households in collaboration with six community based welfare organisations.

The programme was successful in reducing energy costs of the participants [18]. However, since a central contact address was missing and the programme was not intensively promoted, the target group was not sufficiently reached. Additionally the administrative barriers for the loan were very high.

Austria: Energy Consultancy and Refrigerator Replacement Programme (2009-2010) and the Separation Bonus Programme (“Trennungsprämie” 2009-2010)

Free energy consultancies were offered in different projects [19], and old refrigerators replaced with new energy saving devices. Additionally, new cookers, washing machines and boilers were funded. The new appliances were delivered directly into the households without cost and the old ones were properly recycled. Low-income household who had long-term problems paying their electricity bill, and were at risk of their power being cut-off were eligible for aid. In every project just one specific model of refrigerator was offered which lead to a low take-up.

In another programme, the “separation bonus” was available for the whole population regardless of income [20]. A subsidy of €50 or €100 was provided for the purchase of A⁺⁺ rated refrigerators, A rated Washing machines and A rated tumble-dryers from a pre-defined list. Information material for retailers was provided to support the promotion of energy efficient appliances. This programme had such a good take-up that the budget ran out ahead of time.

Germany: Electricity Saving-Check programme (“Stromspar-Check” since 2008) and a contracting programme (since 2012)

In Germany there has been a nation-wide *Electricity Saving-Check programme*¹ [21] since 2008, which helps low-income households save energy, with several low-cost measures. It is organised by the German Caritas Association and the Association of Energy Agencies in Germany (eaD e. V.) and financed by the national Climate Initiative of the German Federal Ministry of Environment. Low-income households receive an electricity saving consultancy at home which is executed by specifically trained long-term unemployed people. The first step is to check the electricity demand of a household and provide well-directed recommendations for electricity saving. The households also receive a package of small energy saving devices such as switchable power strips and energy-saving light bulbs. The household can additionally receive a €150 voucher to buy an A⁺⁺⁺ refrigerator if: 1) the old one is at least ten years old, 2) the fridge replacement saves a minimum 200kWh per year (quantified by a 48-hour measurement of status quo), 3) the old fridge is verifiably recycled and 4) the new one has a similar capacity to the old one. The whole programme is free of charge for the households and evaluated by monitoring. It is available in more than 100 German communities. The Caritas Association employs the consultants and contacts the households supported by 17 regional energy agencies and a handbook for the implementation of energy saving advice for low-income households is provided. The programme has a high media profile and the trained consultants are very motivated.

Even with a €150 voucher an A⁺⁺⁺ refrigerator is expensive, so the consumer advice centre and the municipal energy supplier in Wuppertal provide low-income households (recipients of social transfers, retired persons, students) with a selected A⁺⁺ refrigerator for a low monthly instalment². The precondition is a need assessment and the household has to self-finance the fridge, supported by payment by instalments (a kind of a contracting model) with a subsidy of €50. The selected appliance is chosen for the needs of single parents and retired persons. This is the weak point of the programme, however, as the focus on one particular appliance does not fit every low-income household. For example, families with many children would have problems using this programme.

Other exemplary campaigns, targeted at all households were run in:

- Denmark – campaigns on A to A⁺⁺ rated cold appliances, Danish Electricity Saving Trust, 1999-2008 [22]
- Italy – Tax allowance on A⁺ or A⁺⁺ rated refrigerators, since 2007
- Switzerland – Funding of A⁺⁺⁺ rated cold appliances, top-ten-programme, 1997-2015
- Spain – Funding of A to A⁺⁺ rated appliances, 2005-2012

¹ <http://www.stromspar-check.de/willkommen/> (11.12.2014)

² <http://www.wsw-online.de/unternehmen/artikel/detail/kampf-gegen-energiearmut-wuppertaler-kuehlschrank-austausch-vorbild-fuer-europa/> [15.12.2014]

- Netherlands – Energy Premium Scheme for domestic appliances, 2000-2003
USA – Appliance Rebate Program Helping low-income homeowners, 2011-2012; Habitat for Humanity Refrigerator Replacement Program, ongoing [23]
- Canada – The Refrigerator Replacement for Low-Income Households Program, 2014-2015 (a Hydro-Québec initiative run by MARCON)
- Cuba – Funding of appliance replacement for a low monthly instalment, since 2005

Success factors of policy programmes

As indicated in the international overview, there are barriers and drivers of policy programmes for low-income households. The impact of a funding programme particularly depends on inhibiting and supporting factors which motivate the target group making use of the financial support. Politics should account for drivers and find answers to barriers.

Schönherr and colleagues [24] analysed several policy measures for sustainable consumption to identify these inhibiting and supporting factors. The factors are related on the one hand to the consumers (level of information, individual characteristics, social environment and financial constraints) and on the other hand to the market structure and political framework [25:145f]. Additional insights came from the group discussion with the target group.

The assumed policy measure behind the analysis of barriers and drivers is a refrigerator replacement programme for low income households which combines a subsidy for a new energy efficient appliance with a credit to pay the rest.

Supporting factors

The interest and use of a funding measure depends on individual and contextual factors. These have an impact on the perception of the measure and on the decision behaviour. The following Table 3 shows the supporting factors and implications for a successful policy measure for low-income households promoting energy efficient refrigerators.

It can be seen that the target group might have a great interest in a funding measure of energy efficient refrigerators and the measure might be successful. Existing factors (public discussion) and structures (market development) can be used and intensified.

Table 3 Supporting factors and implications of a policy measure promoting energy efficient refrigerators for low-income households

Supporting factor	Description	Implication
<i>Individual Characteristics</i>		
Level of information	The subject of energy efficiency has a high public profile and matters for the consumer.	The measure should make use of the public discussion.
Motivation to save energy	Due to financial constraints most of the target group are motivated to save energy and see need for action. ³	The measure should utilise the motivated people and use them as propagators to communicate the measure.
Low budget	High energy costs make the funding of energy efficiency and energy saving measures attractive. This is especially the case for low-income households.	Focus of the measure should be the contribution to lower energy costs.
<i>Social Structure</i>		
Word-of-mouth	Parts of the target group use public meeting places and communicate profitable campaigns to others.	A standardised programme eases the inter-regional perception.
<i>Market Structure</i>		
Market for energy efficient appliances	The market for refrigerators is mainly focused on energy efficient appliances and the EU-directive obliges traders to label the energy class of appliances. This leads to a high market transparency.	The necessary infrastructure exists and could be further supported with the measure. This information has to be accessible, credible and understandable.
<i>Political Framework</i>		
Synergies	There often exist other sustainable policy programmes. Interactions of measures lead to a mixing of messages. Policy measures should be synchronised regarding aims, regulations, formal conduct, communication and marketing.	Synergies should be used, and double funding of investments should be prevented. ⁴

³ [10:12], [11], result of the group discussion with the target group.

⁴ [26:39]

Inhibiting factors

Even when the target group has a certain motivation making a claim on the funding there are some individual and contextual factors which could prevent this. Identifying these barriers and their solutions can prevent a failure of the measure. Table 4 gives an overview.

It becomes clear that knowledge gaps as well as financial constraints have to be overcome. An effective marketing concept for a political measure is therefore indispensable.

Table 4 Inhibiting factors and implications of a policy measure promoting energy efficient refrigerators for low-income households

Inhibiting factors	Description	Implication
<i>Individual Characteristics</i>		
Level of information	Knowledge gaps regarding energy saving potentials of appliances have been identified in several studies. ⁵ In particular, the target group does not recognise action possibilities. ⁶	Information on energy saving potentials needs to be provided.
Tendency for withdrawal	A complex and bureaucratic process of application can frighten the (often poorly educated) target group.	Involvement of stakeholders who are in contact with the target group (e.g. social workers), and can support them with their application.
Low motivation	Some of the target group are not motivated to engage with any topic and are not interested in energy saving. ⁵	For them financial incentives and a regional reference is important.
Purchasing routines	Consumers have different preferences as to where and how to buy goods.	Give the consumers as many choices as possible.
Credit limit	High investment costs could be a barrier. ⁷ Low-income households with debts are unable to obtain loans.	The funding has to be sufficient and to be combined with a contracting model or an interest free loan. A ⁺⁺ appliances are usually more favourable than A ⁺⁺⁺ appliances.
Transport	The target group could have difficulties transporting the new refrigerator and disposing of the old one.	Usually the retailer takes care of the delivery and disposal. This is important information for the target group. Possible costs should be funded.

⁵ [10], [27].

⁶ [10], [11], result of the group discussion with the target group.

⁷ [11]

Inhibiting factors	Description	Implication
<i>Social Structure</i>		
Heterogeneity	Different needs and behaviours exist within the target group. ⁸	There is a necessity to address the target groups in different ways (e.g. via different social organisations).
Prestige objects	Refrigerators are usually for everyday use and not considered prestige objects. When they are used as a prestige object there is a trend for big American style refrigerators.	Restrictions regarding the size of the refrigerator are necessary.
<i>Market Structure</i>		
Market development	The state of the art techniques and energy saving possibilities are permanently changing.	The measure has to be flexible especially when it is long-term (e.g. top ten lists have to be updated all the time).
<i>Political Framework</i>		
Top-down vs. bottom-up	A change of mind cannot be reached just through political measures (top down). It also needs motivated consumers (bottom-up).	Intrinsic motivation may not be replaced by extrinsic motivation. This suggests that the funding should not be too high.

Policy recommendations

It can be seen that the funding of a replacement of an appliance alone does not guarantee the saving of energy; some boundary conditions have to be addressed. The combination of 1) meaningful preconditions 2) subsidies 3) payment in instalments 4) energy saving tips and handling instructions and 5) information material for retailers and sellers appear to be the most promising.

This was tried in a German project in 2008 [9] which was quite successful but was only implemented in a small region. The project "implementation of energy efficient measures in Hartz-IV households" („Umsetzung von Energieeffizienzmaßnahmen in Hartz-IV-Haushalten“) was a German study commissioned by the Federal Ministry of Environment. Every one of the above named conditions was considered. The 108 participating households received social benefit but the electricity contingent provided was insufficient. Every household received a free energy check at home and several energy devices. An economic efficiency calculation regarding the investment in a new refrigerator was conducted and if the result was promising the household received a coupon of €200 or €300 (depending on household/refrigerator size). This coupon was directly applied to the purchase at participating retailers. In addition, the households were offered a micro-loan with instalments no higher than energy costs saved each month (a kind of a mini contracting).

Challenges with addressing low-income households

Regarding the financial strain of energy costs and possible options for action, the low-income households seem to be homogeneous. A closer look however, reveals the different demographic

⁸ [19]; [10] [28]

characteristics and the different motivation of the target group regarding environmental matters. There is thus a special challenge to define the target group and communication of the funding programme.

The most comfortable definition of low-income households is the EU-standard: people with an income lower than 60 % of the mean equivalent income of the country. The verification of household income is a very extensive task however, and another option for defining those eligible for subsidies has to be found. In Germany the most practicable solution is to use the “Sozialpass”. This is a document for people in a social pre-care position and is used for example for discounts of museum fees.

Conclusion and Outlook

A policy programme for refrigerators for low-income households not only supports the household but also contributes to the development and diffusion of energy efficient appliances. The energy market share of efficient appliances is increasing over time and this process could be reinforced by political action. Figure 4 shows the increasing number of energy efficient (high energy star rating) refrigerators and freezers as an impact of the labelling and Minimum Energy Performance Standards (MEPS) policies. If retailers, consumers and politics are all inspired, energy consumption can be reduced and the climate protected.

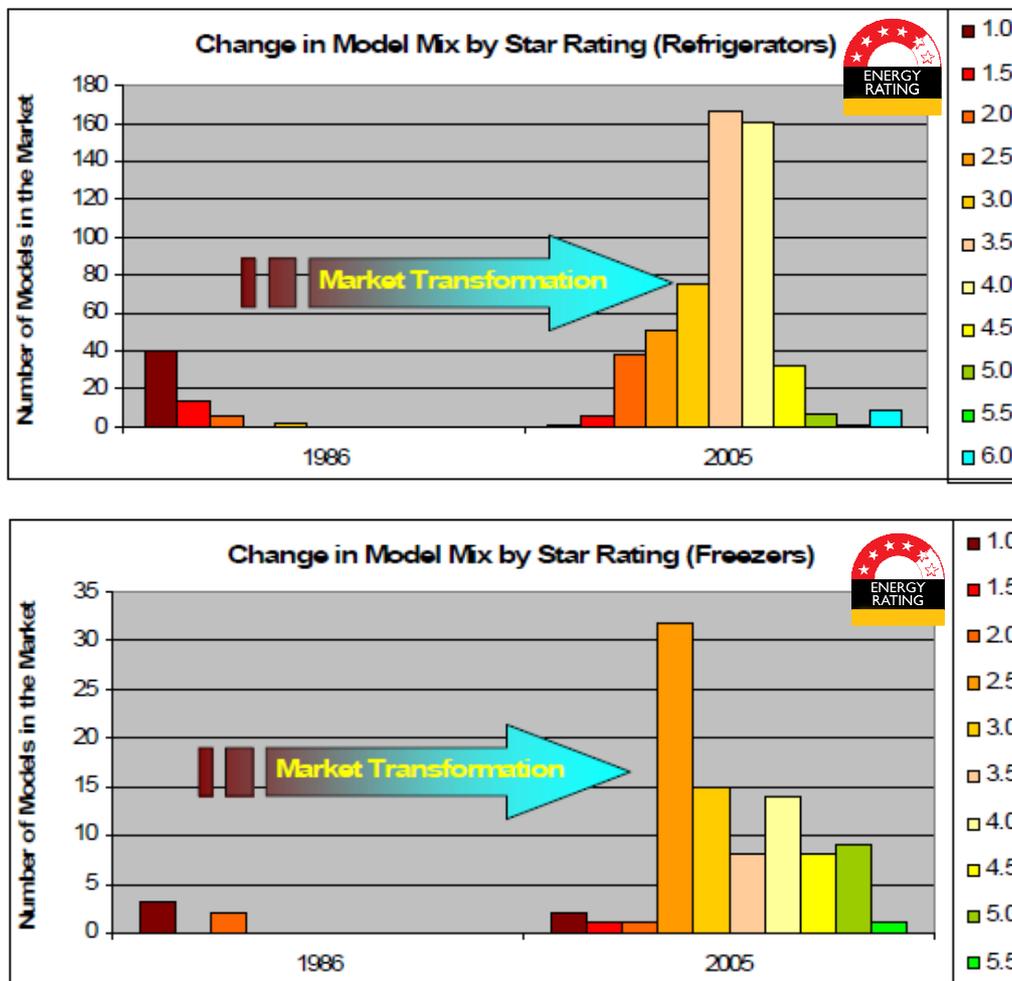


Figure 4 Illustration of Refrigerator and Freezer Market Transformation in Australia between the years 1986 and 2005 comparing number of models by star rating (the higher the more efficient) available in this years [29:44f]

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