# Help or hindrance? Does energy efficiency in general, and product policy specifically, even up income disparity or make it worse?

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## Abstract

Recently, there has been an increasing focus on the wider impacts of energy efficiency policy – beyond reducing costs and carbon emissions. Amongst these impacts is the effect of energy efficiency (EE) policies on income distribution – do they help to reduce or widen the difference in incomes across the region's population; that is, are they progressive or regressive within the region they are implemented?

It is generally recognised that household income has an effect on how consumers use energy and how citizens respond to energy policy. For example, it is hypothesised that lower income groups are generally less able to access the benefits of EE, partly as a result of their lower ability to fund up-front costs of measures. This hypothesis has been tested by researchers for some climate change and EE policies using a variety of theoretical and empirical approaches, producing mixed results. Whilst some studies provide evidence to support the hypothesis, others have found evidence that EE policies focussed on lower income residents have reduced income inequality for targeted households, and some studies suggest that in some countries EE appliances do not in practice incur higher up-front costs and so may not incur distributional impacts.

However, for product policy specifically (including minimum energy performance standards (MEPS), labels, grants), there appears to be a paucity of research using data to evaluate the impacts on income distribution. The few investigations of such impact that have been found tend to be theoretical and focus on implied consumer discount rates and MEPS.

This paper synthesises the literature on the distributional impact of climate and EE policies. It examines the context for product policy, before examining the literature for product policy specifically. Based on this review, some initial product policy implications will be drawn. Finally, it assesses potential data sources that would enable additional research to better understanding distributional impacts of product policy.

## Introduction

Recently, there has been an increasing focus on the wider impacts of energy efficiency policy – beyond reducing consumer running costs and carbon dioxide emissions. These studies examining the wider multiple impacts of energy efficiency show benefits in terms of other aspects considered important to society, such as increases in employment, GDP and innovation (e.g. IEA 2014). For product policy (such as minimum energy performance standards and labels) the benefits to society have also been examined, and recently summarised by the IEA 4E Programme (IEA-4E 2016). The benefits of standards and labels (S&L) are significant, including: consumer financial savings in running costs, increased services, global emissions reductions, and lower than expected increases in purchase prices from regulation. Many of these additional benefits occur directly from the increase in energy efficiency, and the corresponding reduction in energy consumption. Amongst the multiple impacts of energy efficiency (EE) policies is the effect on income distribution – do they help to reduce or widen the difference in incomes across the population; that is, are they progressive or regressive?

Progressive policies have benefits beyond increased social justice. From an economic perspective, there is increasing research to suggest that income inequality is bad for economic growth (Furman and Stiglitz 1998). Furthermore, other research (e.g. an International Monetary Fund staff discussion note) finds lower net inequality is correlated with faster and more durable growth and redistribution does not slow growth except in extreme cases (Ostry et al. 2014).

There is an apparent trend in rising income inequality in rich countries, which may be driving economic stagnation, reducing growth, stalling social mobility, eroding communities, and contributing to other social ills (Nolan 2016). Indeed, such is the perceived importance of this issue, that a recent World Economic Forum report singled out 'income inequality' as the largest risk in the global economy over the next decade, as income and wealth disparity continue to rise (WEF 2017).

Another factor is citizens' willingness to accept environmentally related policies. Some evidence shows that a policy which would be expected to be highly unpopular, such as the introduction of an environmental tax, may be more acceptable if the policy is progressive, benefiting those with lowest incomes (Carattini et al. 2016).

As such this paper aims to provide a literature review of the income distribution impact of climate and energy efficiency policy. It will provide background and contextual aspects that should be considered important for product policy, before undertaking a literature review of the impact of product policy. The paper finishes by providing initial thoughts on the implications for more effective product policy and provides some suggestions on future research approaches to better examine this area.

## Literature review of distributional impact

This section of the paper aims to synthesise the literature on the distributional impact of climate and energy efficiency policies.

### DISTRIBUTIONAL IMPACT OF CLIMATE POLICY

Some aspects of climate policy concern redistribution from wealthy countries to less developed nations, and others relate to climate adaptation. However, in this paper we will focus on the impact within a country of climate mitigation policies that mainly aim to reduce carbon emissions by reducing energy consumption or by increasing low carbon renewable energy within a country. It should be noted that by only looking at climate mitigation policy on its own sets a high bar for whether climate policy in general is progressive or regressive. On the climate impacts side there is lots of evidence to suggest that the impact will be more negative for poorer countries and individuals since they will have less means to adapt. This makes it likely that climate policy as a whole is progressive (at least as far as populations in the future are concerned). However, this aspect is considered outside the scope of the paper. This section will consider climate policy – energy efficiency in general, and product policy specifically, is also part of this climate policy mix, though is considered separately in the following sections.

There is some evidence that with good programme design climate policy can have a neutral or even positive effect on reducing income distribution For example, a study within the German Energiewende found renewable energy policies to be regressive but balanced up by energy efficiency policies which are targeted on low income households (Schumacher et al. 2016).

However, the evidence is not always clear cut. A Joseph Rowntree Foundation report by Preston et al. uses data to model the impact of UK Government domestic energy policy to 2020, and finds it regressive. They find greater gains amongst high incomes (Preston et al. 2013). This follows on from similar earlier work by the main author, which models the effect of UK climate policies and found that they were regressive (Preston et al. 2010). Both reports found that programmes which support local renewables (e.g. photovoltaics and solar thermal) through rebates are generally skewed in favour of higher income households.

In the USA, Fullerton in a National Bureau of Economic Research working paper, considered the effect of a (hypothetical) carbon permit policy[1] income distribution considering 6 different effects (Fullerton 2011). He looked at: 1) higher prices of carbon-intensive products; 2) changes in relative returns to factors like labour, capital, and resources; 3) allocation of scarcity rents from a restricted number of permits; 4) distribution of the benefits from improvements in environmental quality; 5) temporary effects during the transition, and (6) capitalization of all those effects into prices of land, corporate stock, or house values. He found that for this particular case, many or all effects may all be regressive.

A recent study of $CO_2$ taxes in Denmark found that they tended to be regressive, particularly those targeted at households (Wier et al. 2005). A later study of a range of climate change mitigation policies in different countries found that were likely to have regressive distributional implications but that there were several policy options to counteract regressive effects (Büchs et al. 2011).

### DISTRIBUTIONAL IMPACT OF ENERGY EFFICIENCY POLICY

This section considers policy measures which specifically target the improvements in the efficiency of the use of energy. (It can of course form part of wider climate policy.) Here we will focus on residential demand, excluding appliances which will be covered in a following section.

Energy efficiency policies can take various forms, ranging from financial incentives, to fiscal measures, through to government regulation and voluntary agreements. The simplest policy is to regulate the energy performance of new buildings. However, for the majority of the older stock of buildings, retrofit measures are required. For example, energy demand-side management (DSM) programmes, common in the USA, can modify consumer demand through financial incentives or education to install retrofit measures or modify behaviour. Related approaches include mandating a utility or other actor to save energy, usually termed energy (efficiency) obligations or supplier obligations. These are more common in Europe. 'White' certificates can be used in such schemes to certify energy savings made which can then be tradeable and be used within energy saving obligation schemes (see for example, Bertoldi et al. 2010, for further description and analysis). When considering the income distribution effect of energy efficiency policies it is necessary to not only understand the impact of the efficiency

1. Cap and trade system.

measure (where and how much energy saved), but also the funding mechanism and source – for example is the funding from general taxation or from a levy on energy bills?

Like the uptake of subsidised renewables, it is usually thought that wealthier households are more able to purchase/install extra efficiency, due to being better able to fund any up-front costs, perhaps coupled with other aspects. For example, in the USA Sutherland (1994) used the 1990 residential energy consumption survey data (USA RECS data), and found that high income households participated in electric utility DSM programs more than low income. Other examples of this are available, including efficiency obligations in the UK (Moser 2013).

However, if inequity is recognised by policy makers they can implement programmes targeted at low income households. For example, in the UK, various generations of energy Supplier Obligation schemes have tried to do this. The current version – the Energy Company Obligation[2] does take income into account, albeit at a simple level. The Home Heating Cost Reduction Obligation or Affordable Warmth Obligation[3] specifically targets low income homes. Previous versions of the UK supplier obligations have been analysed and researchers have published data and explanations on their outcome/impact. For example, Forfori (2006) lists the impacts, though does not include an analysis of income distribution beyond the headline numbers for measures in the priority group.

A recent UK Government study examined the present effect of policies on energy bills as a proportion of expenditure (not as a proportion of income). It revealed that the package of measures benefits low income households most (DECC 2014, DECC 2016a) largely as a result of measures targeted at lower income 'priority groups' in the Supplier Obligations policy. This policy measure is essentially financed through the energy bills, as an obligation to save energy, not a specific levy or tax. Therefore, households that are slightly above the 'priority group' status may not necessarily receive these benefits.

The energy saving impact of energy efficiency policies is partly dictated by the building energy stock that is its starting point. Research in the UK found that lower income households are more likely to be living in buildings with low Energy Performance Certificate (EPC) scores, i.e. lower energy efficiency. Here, the uptake of building energy efficiency measures is mostly dictated by the nature of the building rather than the occupant, although tenure has an effect (private rented property with the lowest efficiency), as does income. In the UK in 2010 high income households were less likely to have installed measures – probably as a result of the targeted policies just mentioned. The uptake distribution for low and middle income was relatively flat (Leicester and Stoye 2013).

It is clear that good policy is required to ensure low income households are not excluded from the benefits of energy efficiency improvements. Rosenow et al. (2013) reviewed the targeted supplier obligations as a policy to reduce fuel poverty and found them wanting. Others have put forward a way of supporting building energy efficiency in the UK using different approaches for low and high income homes, with low income receiving greater benefit, coupled with overall societal benefits (e.g. higher GDP increase, and cost-benefit ratio of 2,2) (Washan et al. 2014).

A related argument identifies that some households do not necessarily save energy with increased efficiency – rather they increase their use of the service and energy, which is usually termed a direct rebound effect. For example, Chitnes et al. (2014) found that the direct rebound was greatest for low income households (so while the overall benefit is high, direct financial savings are lower, based on simple calculations). This is not surprising. It is reasonable to expect that low income households in houses with poor thermal characteristics and inefficient heating systems, under-heated due to financial constraints, are likely to take back some of the increased efficiency as more heating, rather than saving energy. This is a well-known effect, e.g. low income homes in England have historically taken back as much 30% (Milne and Boardman 2000).

From the review of energy efficiency in general it appears that lower income households are less able to implement energy efficiency measures. However, through targeted policy approaches these distributional impacts can and have been shown to be reduced.

Indeed, a summary review of energy policy by IEA (Geller and Attali 2005) suggests that the impact on household income depends ultimately on the policy design, and points to UK and US programmes which do not penalise low income households.

## Product policies – description and distributive effect

Key product policies are described below, along with their effect on income distribution, where this has been found. There appears to be a paucity of research using actual data to evaluate the impacts on income distribution for each type of product policy. There is also a lack of research which looks at product policy as a strategic whole (strategic combinations of minimum energy performance standards (MEPS), labels, grants, etc.), which should be the context in which they are examined, as it is generally how it is applied, not each policy in isolation. The few research examples on the impact on income distribution that have been found tend to focus on MEPS and on rebates.

### MINIMUM ENERGY PERFORMANCE STANDARDS (MEPS)

#### Description

MEPS are a regulatory requirement which mandate a minimum energy performance for mass produced energy-using products. MEPS are the most effective product policy instruments and are used systematically by governments around the world. For example, in the USA, appliance MEPS have saved significant amounts of energy and reductions in carbon emissions (Meyers, Williams et al. 2014), with similar findings in the EU (René Kemna et al. 2016), and Australia (Lane and Harrington 2010). Recent research has also suggested that, in addition to increasing efficiency, the quality of new appliances also improved (Houde and Spurlock 2015, Brucal and Roberts 2015).

The approach to setting the MEPS standards in the USA and the EU is to undertake cost-benefit analysis of design options, and set performance standards based on minimising the life cycle cost of the service of the product for the majority of people, taking into account its purchase price and running costs (see for example the EU Methodology for Ecodesign of

2. A form of Energy Efficiency Obligation scheme.

3. See information at https://www.gov.uk/energy-company-obligation.

Energy-related Products, Kemna 2011). Any additional costs for the expected increases in efficiency should be paid for by lower running costs. In these analyses, the purchase price is usually expected to rise to pay for the additional mandated energy efficiency. This assumption of increased cost are made prior to the policy being implemented (ex-ante) and is based on evidence available at the time, usually a static analyses of the market prior to regulation and feedback from stakeholders. (This expected rise in purchase price, and actual outcomes after the policy is implemented (ex-post) is discussed below in the distributional discussion).

Theoretically, the main potential losers from MEPS will be those who do not use their appliances as often as the average use which is used to set the standards. Other theoretical losers arise when there are split incentives; that is, where the product purchaser and the energy bill payer are different actors (for example, the case of rented properties where the land lord provides the energy-using equipment, but the tenant pays the energy bill).

*Purchase price increase for increased efficiency?*

Traditionally it is thought that more efficient products cost more to purchase, and that an increase in MEPS performance levels will raise purchase prices and ex-ante analyses of these policies usually make the assumption that this will be the case. However, this is by no means necessarily the case in practice, as some recent ex-post assessments have not found the expected increase in purchase price. For example, ACEEE recently showed that across nine products where US DOE set MEPS, the expected purchase price increase before MEPS implementation was 35 %, though there was no observed increase after implementation (the average price increase was marginally lower, the median marginally higher) (Nadel and deLaski 2013). Similarly, other research also suggests that the expected increase in purchase price is rarely seen, and in some cases purchase prices fall even more quickly following regulation (Lane and Harrington 2010, Spurlock et al. 2013).

#### Distributive effects

Apart from the theoretical losers of MEPS discussed above (e.g. relatively low users), it would appear at first glance that the main distributive effect of MEPS is simply that consumers who buy and use more appliances (generally those on higher income) may have greater gains. However, some researchers (e.g. Sutherland 2003, and Miller 2015) have argued that the MEPS are more regressive than this, based on arguments around discount rates. The lifecycle analyses used to set the MEPS levels use extensive data but also make use of assumptions or premises. One of these is the discount rate to use when comparing the value of future energy savings against the initial cost of purchase. The use of discount rates is common in policy assessment and generally standard rates are used across Government at a given time for all types of policies and across all consumers.

Sutherland argued that mandatory MEPS in the USA introduced costs to consumers, which are borne disproportionately by low- and middle-income households (Sutherland 2003). This analysis was based on using low-income consumers' much higher implied consumer discount rate when they can voluntarily choose energy efficiency. The same argument is made in a recent paper by Miller, using furnace fans as an example (Miller 2015), whilst Newell and Siikamäk (2015) argue the same in a more general case.

Based on a behavioural model of temptation and self-control, a paper by Tsvetanov and Segerson (2014), rebuts the implied discount rate argument. Their findings show that MEPS reduced the 'choice set' in way that benefits consumers. Using their model, they find greater benefits from MEPS for low income households.

The issue of what are appropriate figures to use as discount rates in developing or evaluating all energy efficiency policies is long running and on-going. A current EU H2020 funded project, BRISKEE, (Behavioural Response To Investment Risks In Energy Efficiency[4]) is trying to address this; their programme of work will include a large scale consumer survey.

In an alternative approach, a paper by Fischer (2004) suggests that the distributional impacts of a policy depend on the structure of the market itself. In a theoretically perfect market for appliances, manufacturers will segment the market to gain additional income from high income purchasers who are more willing to pay more for additional efficiency. For these segmented markets, Fischer concludes that MEPS play a useful role both in improving the choice of energy efficiency and reducing the distortion from price discrimination. Following evidence that these markets are not necessarily perfect, Fischer in a theoretical analysis of the effect of an imperfect market, then suggests that MEPS improve the financial situation for the low income consumers.

Moxnes (2004) examined the argument that MEPS efficiency standards prohibit products that represent optimal choice for customers and thus lead to reduced customer utility. Using a conjoint analysis, he finds that MEPS can lead to increased utility for the average customer since customers make imperfect choices in the first place.

A retrospective review of national energy efficiency standards for refrigerators in the USA (Greening et al. 1996), which included some income information in the analysis, found 'standards do not appear to have inhibited installations of new, efficient refrigerators in low-income households'.

All of the ex-ante analyses assume that MEPS increase market prices for products – the additional energy efficiency is expected to come at a higher purchase cost. However, as described earlier, there is increasing empirical evidence that this is not always the case. In such cases consumer's effective discount rate is irrelevant and this mechanism for the policy being regressive does not exist.

### REBATES

#### Description

Rebate schemes for energy efficient goods are a frequent (product based) component of wider energy efficiency schemes such as Energy Efficiency Obligations (in the UK), White Certificate schemes (e.g. Italy) or DSM programmes (in the USA), whereby consumers can buy a product which is at the high efficiency end of those available on the market at a reduced price, or receive cash back. The target of these can range from technology procurement through to increasing the market share of higher

4. See http://briskee.eu/.

efficiency products. Or the rebates may primarily be a financial recycling method; for example rebate schemes which were extensively used in the early 2000s in the Netherlands were part of recycling energy taxes to all households (Siderius and Loozen 2003).

The primary effect on income distribution by rebates is the uptake by the different income groups. However, the level of rebate and the efficiency of the product being promoted are also important. Usually, the rebate makes a more efficient product substantially more cost-effective to the purchaser. In other cases, the rebate may be a symbolic inducement to trigger a more efficient purchase, and may not necessarily be more cost-effective to the householder. In this case if higher income households are more likely to purchase the product, it would be seen as progressive.

Of course, the rebates themselves may be targeted to lower income households to overcome inequality effects, and as part of an overall strategy (e.g. Fridge-saver programme in the UK (Boardman et al. 1997)).

#### Distribution effects

A literature review for the current paper failed to find any economics-based assessment of the distributional effects of rebate schemes for energy efficient goods; although it is believed by the authors that this was undertaken in the past, for example on the first UK Supplier Obligation schemes, EESOPs. The income distribution impact of the Energy Company Obligation scheme[5] to introduce energy efficiency boilers was examined by the UK government using their NEED framework and this did not reveal any regressive impacts (DECC 2016a).

However, an evaluation of a number of residential DSMs schemes run from 2010–2012 in California USA by Frank and Nowak suggests that they may be regressive (Frank and Nowak 2016). They found that for most (untargeted) programmes that participants were not representative of the population: – high income, more educated, white households participated at a rate which was higher than their presence in the general population. However, they also found that where schemes were focused on particular communities (very much the minority of programmes) that this targeting was effective, so, as for other policies examined so far, it seems possible for policy makers to influence the distributive effect.

### ENERGY LABELS

#### Description

Generally, there are two main types of labels: voluntary endorsement (such as ENERGY STAR) and mandatory comparative (such as the EU A-G Energy label). The rationale for their introduction is to support the correction of a market failure, namely imperfect knowledge, by providing information to consumers. However, they can also be used by companies to differentiate their products. The aim of such policy is to pull the market towards more efficient products being marketed and sold. A handbook by CLASP provides a useful overview of the types and use of labels, and how they can be integrated into other policy measures to improve the efficiency of products being sold (Wiel and McMahon, 2005).

#### Distribution effects

Under labelling, the consumer purchase is voluntary in nature; and as such, the income effect will depend on the structure of the market itself. For example, in a hypothetically perfect market, labelling will enable households to identify and purchase any extra efficiency which costs more. In this case, higher income households may be better able to purchase this extra efficiency.

However, for the UK and in many regions, the market for efficiency of products is not perfect. A report funded by Defra found the link between price and energy efficiency for most appliances was weak so product charges on energy efficient appliances were unlikely to be regressive (Pittini et al. 2003 reported in (Oxera 2006). This is usually the case prior to product policy being introduced (e.g. Boardman et al. 1997). As shown earlier, higher energy efficient products are not necessarily sold at higher prices – if only because manufacturers and retailers charge different margins for ranges marketed at different segments of customers. Also, in very competitive markets, such as those for consumer electronics, manufacturers are thought to absorb any additional costs of energy efficient components rather than passing them on to the consumer.

In some countries there are, however, pronounced differences in market segmentation. For example in South Africa, high and low income households tend to choose very different appliances (on brand, and increasingly efficiency) (Covary et al. 2015, Tholen et al. 2015).

One study looked at the impact of the ENERGY STAR endorsement label for light bulbs (Sahoo and Sawe 2015). They found that whilst most individual consumers did benefit and society overall benefits, some consumer did lose out. Although different impacts were observed, their research did not examine income.

### MARKET TRANSFORMATION STRATEGY (DESCRIPTION)

In an ideal world, individual product policy measures (such as labels, rebates and MEPS) should be considered as part of a strategic approach to increase the efficiency of products sold (DECADE 1997, Hinnells and McMahon 1997, Wiel and McMahon 2005). At the simplest level, labels should be employed to provide information to the consumer to aid a more informed choice, and provide an incentive for the supply side to market more efficient products. The use of procurement and rebates should be used to expand the production and uptake of more efficient products. These financial incentives may have different underlying motives and aims, though within a market transformation strategy they should result in expanding the market for more efficient products, and lowering their costs through higher production runs, and pulling the market. This in turn means that MEPS can be implemented at a more stringent level than simply removing the least efficient from the market. By repeating this process, MEPS performance levels can be gradually ratcheted up over a period of time, ensuring the persistence of futures energy savings. While this ideal of a strategic approach is rarely achieved in most countries a mixture of policies will apply at any given time, and any impact assessment should be undertaken in the context of the aims and implementation of these multiple policies.

5. The current version of the Supplier Obligation scheme.

It should be noted that product policy overall has been found to be very effective. There is a substantial body of evidence that the energy efficiency of new appliances continue to improve; at rates greater than even if no policy was in place (IEA-4E 2016). Additionally, purchase prices continue to fall and the quality of products is rising (Houde and Spurlock 2015, Brucal and Roberts 2015). The energy savings, carbon emission reductions, and other related benefits mean that overall the benefits outweigh any additional costs to the public as a whole. The IEA 4E Achievements report (IEA-4E 2016) provides the most recent literature review of the multiple benefits of product policy around the world. This IEA meta-analysis provides clear evidence that efficiency of appliances is improving significantly, at lower costs than expected, and providing multiple additional benefits. However, this study did not make any comment on the distributional impacts of product policy. This appears to be a major gap in the understanding of the impacts of products policy.

## Possible sources of evidence/issues for distributional effects of product policy

The previous section has tried to find evidence or literature which cites the income distributional impact of products policy. This lack of evidence may mean it is has not been considered an issue to date, or that answering this question is not trivial. Whatever, the reason, there is a clear knowledge gap. Filling this gap would be useful, especially with increasing attention given to income distribution in society. This section will describe some possible sources of data to allow further investigation into the impact of product policy on income distribution, and also discusses related issues.

### HOUSEHOLD ENERGY SURVEYS

For a better understanding the income distribution impact of labels and MEPS, detailed surveys of households who have recently purchased an appliance provide an ideal approach to obtaining direct evidence. Such a survey was done in the UK in 1995 after the introduction of labels, coupled with a survey on the availability of products in the stores (Boardman et al. 1997). However these are not common and the authors have not been able to identify any other similar published examples.

Large official surveys of the population with respect to energy use and including income do exist, although they do not usually collect data on the efficiency or purchase price of new products installed within the same framework. For example in the USA, their national Residential Energy Consumption[6] (RECS) survey, undertaken periodically[7], samples a very large number of households, selected to be nationally representative, over a wide range of topics. However, whilst they would ask questions on ownership of appliances, as do similar national surveys around the world, they do not ask detailed questions on the efficiency of recently purchased products. To overcome these data and information gaps, researchers who use such national data to infer insights into product policy have to make additional inferences from other data sources. For example, Sutherland (1994) and Miller (2015) have used RECS data and tried to tie these to industry data on sales of energy-using equipment to make inferences of the impact on income.

Ideally, more in-depth questions on the energy efficiency of appliances would need to be added into these national surveys.

### PROFESSIONAL MARKET RESEARCH PANELS

There are market research companies who have existing panels of householders who can be used to explore these more bespoke questions on purchases and impact of income. These panels, which represent in the order of tens of thousands of households, should be sufficiently large to provide a sufficiently representative sample of the income distribution of the population who have purchased appliances. At present, there is no evidence of these being used to do this type of analysis for income distribution effects of product policy directly – though it is clearly possible to undertake these, at a cost of course.

### HOUSEHOLD ENERGY USE MEASUREMENT (METERED) SURVEYS

Over the last few years, there has been an increase in the monitoring of energy consumption by individual appliances in the home, for example in New Zealand and Sweden (Isaacs et al. 2006, Zimmermann 2009). These metering campaigns, coupled with information on household income and appliance purchasing patterns should provide a very detailed insight into the actual inter-relationship between income and the number, type and efficiency of products the households have in their home. However, such surveys are still relatively small (Sweden had 400 homes, UK fewer), and although they are becoming cheaper to deploy, there are still too expensive to provide sufficiently large scale campaigns to infer any robust evidence on income distribution effects of product policies such as labelling and MEPS.

### AUTOMATED DATA COLLECTION

At present, information on the energy consumption of homes is provided from a single meter– it does not provide information of particular end-uses, which is where product policy regulation has an impact. Intrusive metering campaigns have been used to fill in some of this gap. However, it is increasingly envisaged that it should be possible to partly fill this gap by collecting energy-related data from energy-using appliances directly. ‘Smart' appliances those with internet communication ability, could have this capacity and would be then able to centrally log such information. This future ‘Internet of Things' is still in its infancy, and has multiple issues still to address, not least privacy ones. However, it does provide some future opportunities for better understanding energy use at a detailed level, at a low cost.

A different approach to estimating end-use consumption is being done by analysts trying to disaggregate the total house energy consumption from smart meters. By sampling at a sufficiently high rate, it may be possible to disaggregate the data signal using known patterns and disaggregation techniques (OECD/IEA 2016). In both cases information on the household income would still be needed in addition in order to examine income distributive effects.

### MARKET DATA ON PRODUCT PRICES

Analysis of market purchase prices over time and region is very useful. These are currently available from market research companies through various means including using links with

6. See https://www.eia.gov/consumption/residential/about.php.

7. The most recent survey for which data are published was in 2009. A survey was done in 2015, but the complete results are not yet available.

retail outlets. These provide invaluable insights into the cost of products and features (enabling analysis on the effect of higher efficiency on market price), though are expensive to purchase routinely. Recent developments in 'web-crawling' and 'data scraping' should soon provide analysts with a lower cost option to retrieve large amounts of such data (OECD/IEA 2016).

#### ANALYSIS OF PROGRAMME 'APPLICATION' DATA

For rebates or loan programmes, where there is a clear funding or audit trail, it should be possible to assess the income impact of the scheme using information collected as part of the scheme. These should all be part of good governance and good practice evaluation of the programmes themselves. The income distribution of those taking part in the programme can be mapped against the national average to provide a clear insight into the uptake of each policy by different income groups.

For example, in the UK, these data have been collected for the Green Deal, ECO and feed-in tariffs programmes. Importantly, these examples have been collated centrally, which has enabled a more sophisticated analysis to be undertaken when integrated with other information from other sources.

However, not all programmes do this or if they do, they do not publish the results. For example, Frank and Nowak (2016) found of the 42 California DSM programme evaluations they reviewed only 29 collected demographic data from the participants and only 20 of these published these data.

#### EVALUATIONS OF PRODUCT POLICY

Some detailed ex-post evaluations of past product policy exist, e.g. Australian policy measures on new residential refrigerators and air conditioners (Lane et al. 2011). These examined all the ex-ante assumptions and compared them to the actual outcomes after the regulations had been implemented (size, efficiency, sales, ownership, price) and undertook a decomposition analysis to show the impact of the 'errors' made in the assumptions. These S&L policies were shown to be highly cost-effective overall, and significant increases in efficiency were gained with little or no increase in purchase cost (less than the ex-ante studies suggested). Such detailed evaluations are however, still rare. For example, the EU impact assessment of Ecodesign primarily makes use of the ex-ante assessments, and have not been fully re-appraised to reflect later data. And even these, did not examine income distributional impacts – they would have needed additional data on the distribution of sales of type by income to examine this aspect.

#### INTEGRATING DIFFERENT DATASETS

In the UK, the National Energy Efficiency Data-Framework (NEED) project was set up by the Department of Energy and Climate Change[8] to assist in its plan to promote energy efficiency with the Green Deal and support vulnerable consumers. It has collated a large dataset from various sources and tied together using a unique property address. The data sources include: information from the energy efficiency programmes themselves, property information from the Valuation Office Agency (VOA), household characteristics from a credit agency Experian, and household energy consumption from energy suppliers.

It has provided the basis for a detailed analysis of electricity and gas consumption by property attribute, household characteristics, geography and socio-demographic classification (DECC 2016b). This approach thus enabled the analysis of several energy efficiency measures introduced in the UK, though it currently does not include information on appliances or lighting.

## Conclusions, policy discussion, further research

Income inequality is increasingly seen as an important issue – significant at the local, national and global scale, with potentially widespread negative effects. So it is worth asking the question – what is the implication or outcome of policy in relation to income inequality?

Based on the literature review undertaken, there are some studies that attempt to answer this question for climate and energy efficiency policy. However, to date, this has not been extensively addressed for product policy.

#### SOME INITIAL CONCLUSIONS AND CONSIDERATIONS FOR PRODUCT POLICY DESIGN

The evidence for distributional impacts for product policy is not entirely clear cut, and further research is needed to understand this impact further. Even so, based on this initial literature review above, it is possible to draw some conclusions and initial implications about policy design options available to mitigate distribution risks of product policy.

##### Implications for MEPS

Stringent MEPS, even as stand-alone policies, have been proven to be very effective. The main equity concern comes from potential increased purchase prices consumers would face which, when combined with higher effective consumer discount rates for low income households, would mean low income households may suffer relative to higher ones even if the overall impact is positive. There is evidence that the expected increase in purchase costs due to MEPS have not materialised in practice, so this may not be a valid concern. However, most of this evidence comes from the USA, with some from Australia. Supporting data and analysis from other countries would make this finding more robust and generic.

There remains the issue that, higher income groups may gain more from MEPS if they are purchasing and using more appliances. However, this should not be taken to mean that the use of MEPS regulations should be restricted or the performance levels reduced. In fact, with increasing evidence of falling purchase prices, especially when driven by such regulation, there is an argument to make them more ubiquitous and even more stringent (Lane et al. 2013).

##### Implications for rebates

Rebates can be very effective at developing a market for more efficient products, especially when used as part of a market transformation process. It is usually noted that rebates can be more easily taken up by wealthier households and some reviews support this statement. There are, however, options to ameliorate this income inequality impact, such as having policy rebates targeted at lower income households. Other methods

8. Since June 2016 part of the Department for Business, Energy and Industrial Strategy.

can focus on retrieving savings at a later date, e.g. loan guarantees (though these have been less successful) which may increase uptake in lower income households.

#### Implications for energy labelling

The implications for energy labelling are uncertain – they have not been examined and the possible effects are many. These labels are sometimes used by policy makers to target specific measures (such as rebates or loans). As such, they need to be implemented to enable other policies, some of which could be targeted on low income households.

Comparative labels (such as the EU A–G) should be regularly revised, especially to 'leave space' at the high efficient end of the scale, where additional efficiency may well cost the consumer more (at least in the short term). Manufactures have tried to link high efficiency with high quality brands[9], so a price premium may emerge if the comparative label thresholds are set and revised appropriately. It is likely that higher income households will purchase these products, and in these circumstances they will be purchasing efficiency at a higher cost. In this case, the label will be progressive. In a similar manner, the performance levels for voluntary endorsement labels should be set in conjunction with the aims of other policies, and not simply set in a policy vacuum. For example, voluntary levels may be set with the intention of these being the values for future performance levels for rebates or future label or future MEPS performance thresholds.

Generally the policy implications for product policy reflects the findings for 'higher level' policies – climate change mitigation policies and more general energy efficiency policies – that with a combination of careful design, targeting and combining different policies in a package the net income distribution effect can be made neutral, or even progressive, that is reducing income disparity. However, more detailed data and analysis is necessary for this to be properly understood and addressed appropriately.

### RESEARCH GAPS AND PROPOSED AGENDA

Based on this initial literature review, there appears to be some merit in further examining the income distribution effects of product policy – for each policy separately and applied as a package where appropriate. There appears to be a paucity of evidence around understanding of the income distribution impact of current policy, and studies that have been carried out have contradictory findings.

A more detailed literature review may find additional evidence and insight into the distributional impact of product policy. However, it is likely that more primary research is needed.

Understanding the link between household income and the efficiency of the products they purchase would seem to be an essential step. This requires some empirical data – most obviously gathered via surveys. At the simplest level this would be for a sample of data from a representative number of householders who purchased appliances in the previous year (or smaller time period). Market research companies have existing capacity to undertake bespoke analysis relatively easily. In England and Wales, there is the opportunity to further explore the NEED energy efficiency framework, and seek opportunities to expand the collated integrated data base to include purchases of energy-using products. In addition to these more conventional approaches to surveys, there may be opportunities from new approaches to collecting data – from emerging 'apps' through to 'smart' metering of equipment.

Also fundamental is better information of the extent to which the market values greater energy efficiency. Questions would include: what is the price/efficiency range? How widely does this vary between countries? How widely does that vary between different types of products? Is it possible to separate the effect of energy efficiency from other, associated, features such as quality and brand?

Evaluation of product policies is relatively rare; more information on their impact would be helpful; particularly their effect on product price.

In summary, product policy has been proven to be highly cost-effective at improving efficiency, reducing global energy consumption, and running costs for consumers. There is however, some evidence that product policy, especially if used inappropriately can be regressive. The amount and quality of research into this aspect is particularly low. As such, given the increasing importance of global income inequality it is worth further exploring the income effect of such policies, especially the extent and drivers; with the ultimate aim of using this improved knowledge to ensure the design of more robustly progressive policies.

9. For example, Boardman et al. 1997, showed that following the introduction of mandatory EU energy labelling branded refrigeration appliances in the UK were, on average, around 5 % more efficient than non- or own-brand appliances.

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