eceee Summer Study proceedings

Affordability of energy efficient appliances – indicators and evidence

COLLECTION: BUILDINGS AND APPLIANCES

PEER-REVIEWED PAPER

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ABSTRACT

Peer-reviewed paper 8-181-26

As the political debate around energy security, climate action, energy justice, and broader social issues evolve, the link between energy efficiency and affordability has become increasingly important for policy-makers. This paper presents recent scoping research and other evidence on the relationship between energy efficient product policy and affordability.

Drawing on a literature review and targeted analysis, the study identifies practical approaches to improving access to energy-efficient appliances and to better integrate affordability considerations into policy-making. It reviews how affordability is defined across different fields, and examines both traditional and alternative metrics that provide frameworks for assessing affordability.

The literature shows that low-income households are less likely to adopt energy-efficient appliances. Several studies find a positive correlation between energy efficiency and purchase price, with more efficient appliances often costing more upfront. However, evidence also indicates that higher efficiency does not always require higher prices and that, with appropriate policies, efficient appliances can be cheaper over time. In addition, lifetime household costs are typically lower, as improved efficiency reduces energy consumption.

Despite these benefits, significant barriers remain for low-income users, including high initial prices, limited access to financing and insufficient consumer information. Additional challenges include the limited availability of low-cost efficient models and the exclusion of certain appliance types from regulatory schemes, such as shared commercial appliances.

The paper aims to support policy-makers by informing improved policy design and implementation, fostering a more differentiated understanding of energy efficiency that incorporates technological, social, and economic dimensions. It also identifies areas for further work, including assessing the suitability of different affordability indicators.

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KEYWORDS:
MEPS; price; indicators; households; products; appliances; energy efficiency

TO CITE THIS ARTICLE:
Lane, K, Díaz, A and Attali, S. 2026. Affordability of energy efficient appliances – indicators and evidence. *eceee Summer Study proceedings*, 1(1): 38, pp. 1–14. DOI: https://doi.org/10.66506/essp.8-181-26

DOI: 10.66506/essp.8-181-26

INTRODUCTION

As political discourse surrounding energy security, climate action, energy justice, and broader socioeconomic concerns continues to evolve, the relationship between energy efficiency and affordability has emerged as an increasingly important consideration for policy-makers (IEA, 2026).

Affordability is broadly defined as the capacity to pay for goods and services without incurring undue financial hardship; or alternatively, the relative ease with which a consumer can access and purchase a product or service. In essence, it constitutes a measure of the relationship between expenditure (economic cost) and income (purchasing power).

For some bodies, including the European Union (EU), the concept of affordable energy is intrinsically linked to the issue of energy poverty, defined as the condition in which "a household must reduce its energy consumption to a degree that negatively impacts the inhabitants' health and wellbeing" (European Commission, 2026). Among the primary mechanisms proposed to address energy poverty is the provision of affordable energy. The EU has outlined seven policy actions to this end, two of which warrant particular attention: first, reducing electricity costs for consumers through more efficient utilisation of the grid and a reduction in electricity taxation; and second, advancing energy efficiency through energy savings facilitated by product energy labelling and ecodesign requirements. Energy efficient and demand flexible products can support affordable energy services.

For appliances specifically, there are several expenses for consumers associated with appliances, most importantly, one-off purchase cost and the ongoing running costs. These are two separate affordability considerations, although they are interlinked as a different purchasing decision or requirement may affect the efficiency and implied ongoing running cost of an appliance. It is this aspect of purchase price versus efficiency that is at the heart of product policy.

The present paper focuses specifically on the affordability of household appliances, and especially the role of Minimum Energy Performance standards (MEPS, or ecodesign energy requirements). A recent overview of affordability at the household level, which included an initial examination of appliance affordability, underscores the timeliness of this inquiry (IEA, 2026).

This paper proceeds as follows. It first reviews the effectiveness of product policy in improving energy efficiency, reducing operational running costs, and any influence on purchase prices over time. It then examines affordability considerations in the context of setting Minimum Energy Performance Standards (MEPS), drawing on a range of existing household affordability metrics. National-level estimates are presented as illustrative examples, accompanied by recommendations for methodological development. The paper concludes with a discussion of policy implications and directions for future research.

ROLE OF POLICY TO IMPROVE APPLIANCE EFFICIENCY AND AFFORDABILITY

Energy-using appliances and products are fundamental to modern living, underpinning essential services such as space and water heating, cooling, refrigeration, lighting, and entertainment. Many of these services are delivered through mass-produced equipment, manufactured and distributed at scale.

Since the 1980s, many governments consider policy packages as part of an energy efficiency policy toolkit (IEA, 2025) for improving the efficiency of energy-using products sold, comprising three main components, which are used in a strategic way:

- **Regulation**, through Minimum Energy Performance Standards (MEPS) – implemented, for example, under the Ecodesign Directive or the Ecodesign for Sustainable Products Regulation (ESPR) in the EU – which aims to remove the least energy efficient products from the market;
- **Information provision**, which may be mandatory, such as the EU's A–G energy label, or voluntary, such as the Energy Star scheme; and
- **Incentives**, such as consumer rebates, designed to encourage the uptake of more efficient product and support some members of society.

DOI: 10.66506/essp.8-181-26

In Europe, most appliances are subject to efficiency regulations; whilst more broadly, over 100 countries now employ MEPS or labelling schemes to improve appliance efficiency. Consequently, consumers in such countries are no longer able to purchase the least efficient appliances.

This policy approach has proven highly effective in Europe (European Commission, 2025). Globally, these policies have been shown to be highly effective across multiple countries and regions (4E TCP and IEA, 2021). A cost–benefit analyses of Energy Efficiency Standards and Labelling (EES&L) programmes conducted across multiple jurisdictions, indicated that the financial benefits arising from reduced energy consumption and lower utility bills outweigh both the additional costs associated with purchasing more efficient equipment and the administrative costs of programme delivery. For example, the United States EES&L programme generates net savings of approximately USD 40 billion per annum for households and businesses, with the average annual household energy bill reduced by USD 320. Across all jurisdictions the average benefit-to-cost ratio was approximately 4:1 (4E TCP and IEA, 2021).

Beyond direct financial savings, EES&L programmes have also demonstrated significant employment benefits. In Europe, for instance, the programme generates approximately one million direct jobs per year, with one additional job created for every EUR 80,000 invested (via higher consumer purchase prices) in more energy-efficient equipment (4E TCP and IEA, 2021).

A small body of literature exists which examine the relationship between appliance policy and distributional impacts. Distributional impacts relate to those with a change burden or benefit to the regulation (usually consumers, government or industry). However, these studies identify a notable shortage of robust data from which firm conclusions can be drawn on the changes in impact on different actors, e.g. (Lane et al., 2017).

PRICE VERSUS EFFICIENCY – A KEY QUESTION

For consumers, the upfront purchase price represents the primary affordability consideration: as purchase prices increase, affordability commensurately decreases. At the most fundamental level of analysis, it is possible to illustrate the relationship between purchase price and energy efficiency across products available on a given market at any point in time.

Notably, for some markets, there is a relatively low price premium exists for greater energy efficiency – as implied for air conditioning (AC) equipment in selected regions in Figure 1 (IEA, 2026). Consumers can purchase more efficient products which do not cost more.

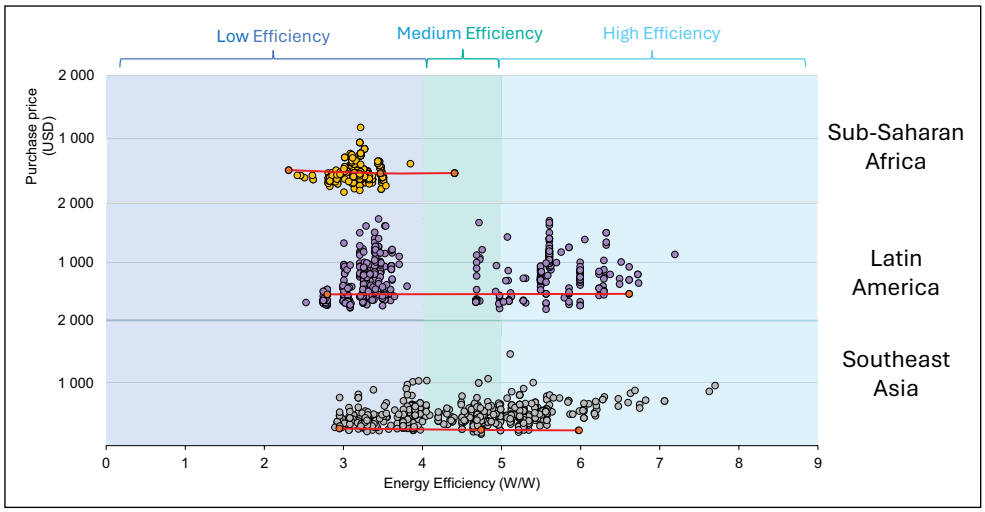

Figure 1 In-store price versus efficiency for air conditioners, various regions (IEA, 2026).

Although, this potentially surprising pattern can be observed, in many markets a positive correlation exists between purchase price and energy efficiency. Figure 2 (left) illustrates this relationship for AC equipment in a representative market, where, on average, products with higher efficiency ratings (as measured by the Cooling Seasonal Performance Factor, CSPF) command a higher purchase price.

When the life cycle cost – defined as the sum of the purchase price and the total lifetime running cost – is plotted against efficiency, it becomes apparent that the minimum life cycle cost corresponds to a more cost-effective product (Figure 2, right) for consumers. This suggests that, from a long-term financial perspective, consumers could rationally afford to purchase

highly efficient AC units, even where the upfront purchase price is higher. It is this tension between up-front affordability for consumers and longer-term benefits that product policy aims to address. And for MEPS especially, how much should mandatory policy push requirements that may require a higher purchase price.

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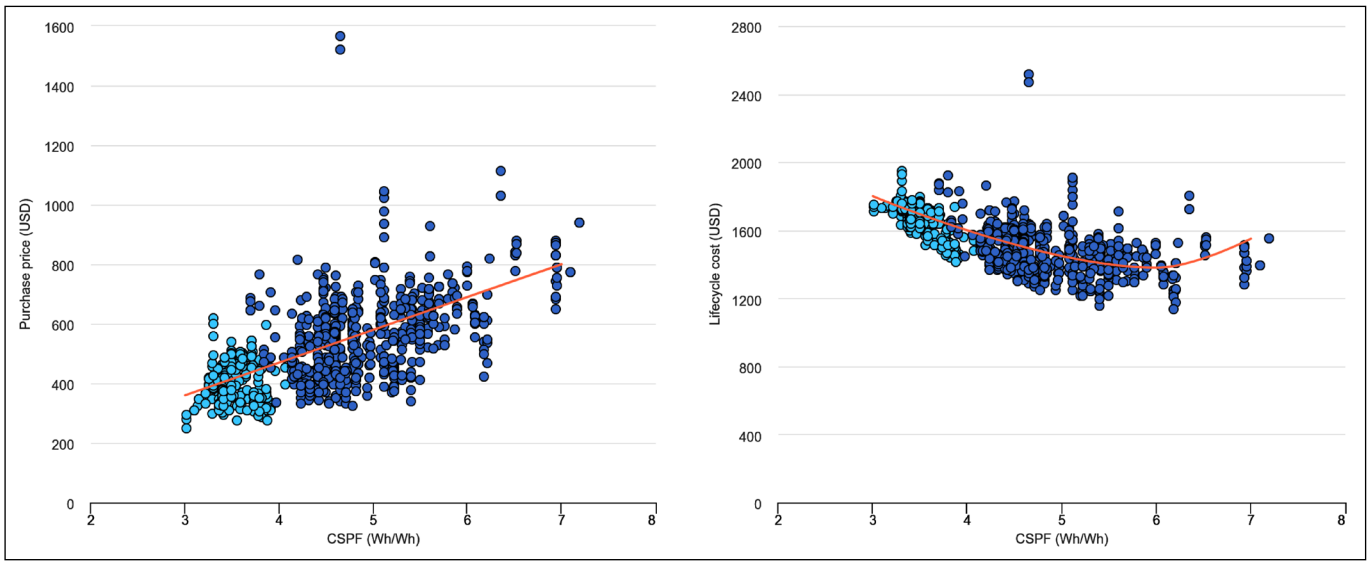

Figure 2 Purchase price versus efficiency, and life cycle cost vs efficiency for AC, Viet Nam (IEA, 2022).

A related question for this paper arises – if, and how, the life cycle cost relates to the concept of affordability. Especially if the purchase price of products becomes higher with increased efficiency, and this one-off purchasing decision is less affordable. This is the clear tension between optimising long-term costs with short term affordability.

Notwithstanding the financial case for more efficient products, consumers may fail to purchase them for a variety of reasons. Commonly identified barriers include:

- **Information deficits**, whereby consumers lack awareness of the efficiency characteristics or long-term cost implications of available products;
- **Upfront cost constraints**, where the higher initial purchase price of more efficient products presents an affordability barrier (lack of capital for instance), despite lower lifetime running costs; and
- **Split incentives**, arising where the purchasing decision and the ongoing energy costs are borne by different actors – for example, in landlord–tenant arrangements.

It is for these reasons that governments take this into account when they design their MEPS and energy labels. In many jurisdictions, MEPS are employed to restrict market availability to higher-efficiency products. These standards are typically set at or around the minimum life cycle cost, although regulators may rely on engineering analysis rather than prevailing market data to estimate the cost of incremental efficiency improvements – an approach that may yield cost assumptions that are either lower than current market prices or based on technologies or appliances not yet commercially available. Similarly, mandatory labels are introduced, in many cases categorical on a multi-level scale, to make easy comparison for consumers.

Although the price-efficiency comparison on a static market is important, the temporal dimension is particularly important in this context. Product policy – and MEPS in particular – has been demonstrated to be highly effective in driving efficiency improvements across product markets over time. A global assessment published jointly by the 4E Technology Collaboration Programme (4E TCP) and the International Energy Agency (IEA) provides robust evidence on the evolving relationship between price and efficiency (4E TCP and IEA, 2021), with two key findings of direct relevance:

- Based on evidence drawn from countries with established EES&L programmes, the average energy efficiency of new major appliances increased at two to three times the underlying rate of technological improvement. This resulted in average energy consumption reductions of 10–30% over 15 to 20 years across the stock of most regulated products. In leading countries with strong, long-running, and regularly updated programmes, the contribution was substantially greater, with EES&L programmes facilitating reductions in appliance electricity consumption of over 50% for many product categories.

- Efficiency improvements have been accompanied by concurrent reductions in purchase prices. While more efficient appliances are sometimes priced at a premium upon first introduction to the market, the average purchase price of appliances covered by EES&L programmes declined at a rate of approximately 2–3% per year – reflecting manufacturers› capacity to adapt rapidly to new efficiency requirements. Consequently, governments have typically overestimated the likely cost impact of proposed future MEPS on purchase prices by a substantial margin, suggesting that more stringent standards could, in many instances, have been adopted.

TECHNOLOGY LEARNING RATES AND FALLING PRICES

The relationship between regulatory standards and product purchase prices has been the subject of dedicated empirical investigation. From 2011, the United States Department of Energy (DOE) began incorporating learning rates into its appliance standards analysis – a methodological approach that explicitly accounts for the tendency of product prices to decline as manufacturers accumulate production experience and achieve economies of scale (Desroches et al., 2013, US DOE, 2011). Empirical validation of this approach has been provided by comparisons of predicted and observed prices following the introduction of appliance standards, which broadly confirm that price forecasts based on learning rates offer a more accurate reflection of market outcomes than traditional engineering cost estimates (Nadel and deLaski, 2013).

Further evidence suggests that regulatory policy may itself have accelerated the rate of price decline. Van Buskirk et al. (2014) propose that energy efficiency standards may have hastened the fall in appliance prices by compelling manufacturers to invest in process innovation and also to scale up production of higher-efficiency products – effectively bringing forward cost reductions that might otherwise have occurred more gradually through autonomous technological progress.

Although not the key question of up-front affordability, the question of whether energy efficiency standards impose a net cost burden on consumers has also been examined directly. Econometric analysis of household appliance sales data indicates that, on balance, standards do not harm consumers – with efficiency-driven purchase price increases, where they occur, offset by reductions in operating costs over the product lifetime. A more recent and comprehensive review has reinforced this conclusion, finding the overall consumer welfare impacts of appliance efficiency standards to be broadly positive (National Academies of Sciences and Medicine, 2021).

Nevertheless, despite the twin trends of improving efficiency and declining average purchase prices, upfront costs may remain a meaningful barrier for certain consumer groups. Households with limited capital resources or constrained access to consumer credit may face difficulty in meeting the initial purchase price of more efficient appliances – even where the long-term financial case is favourable. This distributional dimension of affordability warrants explicit consideration in the design and calibration of future MEPS, and is examined further in the sections that follow.

ISSUE OF LOWER INCOME, DISTRIBUTIONAL IMPACTS

There is consistent evidence that lower-income households tend to own and purchase less energy-efficient appliances than their higher-income counterparts. This pattern has been documented across multiple national contexts and reflects a complex interaction of financial constraints, market structures, and information barriers (Schleich, 2019). The implications are significant: households least able to absorb high energy bills are, paradoxically, often those incurring the greatest running costs because of operating less efficient equipment.

A contributing structural factor is the scarcity of affordable, high-efficiency models at the lower end of the market. This scarcity may arise where the most energy-efficient appliances are positioned as premium products, bundled with additional features and functionalities unrelated to energy performance, thereby commanding price points that are inaccessible to lower-income consumers. Market data for some products in some jurisdictions show this pattern, indicating that energy-efficient appliances can be priced higher than less efficient equivalents (e.g. IEA 2022, presented above), effectively concentrating access to efficiency

DOI: 10.66506/essp.8-181-26

gains among higher-income households, or those that have the information and can make the upfront costs in these cases.

A further dimension of this issue concerns product categories that fall outside the scope of existing regulatory frameworks. Appliances installed in larger multi-occupancy residential buildings – such as communal washing machines – are frequently of a commercial type and may not be subject to the same MEPS that apply to domestic products. This regulatory gap can further limit access to efficient appliances for residents of such buildings, who are often disproportionately drawn from lower-income groups.

A related, though distinct, concern – and one beyond the primary scope of this paper – is the prevalence of second-hand appliances among lower-income households. Older appliances are generally less energy-efficient than current market offerings and may present additional functional deficiencies; refrigerators, for example, deteriorate with age and become progressively less effective at food preservation, with potential implications for household food security. The ownership of second-hand appliances is notably associated with lower-income households and those in rented accommodation, including properties managed by Registered Social Landlords (RSL), where tenants typically have limited agency over appliance selection (Gemmell et al., 2017; see Figure 3). This intersection of tenure, appliance age, and energy efficiency merits more systematic empirical investigation than has hitherto been undertaken.

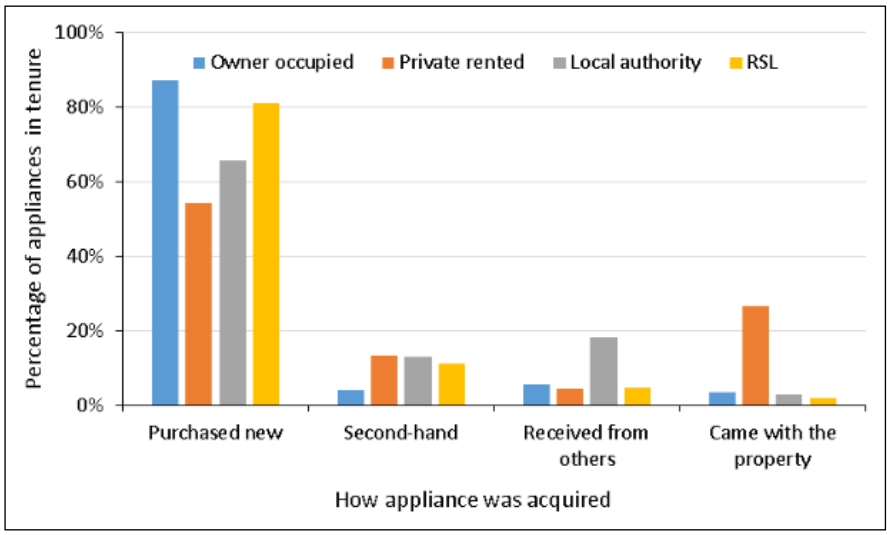

Figure 3 How refrigerators are acquired by households in GB (Gemmell et al., 2017).

MEPS AND REFERENCE TO AFFORDABILITY OR DISTRIBUTIONAL ANALYSIS

Key MEPS-related policies in EU and US already consider affordability, and specifically the impact of first cost in their regulations.

EU ECODESIGN FOR SUSTAINABLE PRODUCTS REGULATION (ESPR)

The EU Ecodesign for Sustainable Products Regulation (ESPR) (European Parliament and Union, 2024) establishes an explicit requirement that implementing measures shall produce no significant negative impact on consumers with respect to the affordability of relevant products. This provision encompasses broader considerations of access to second-hand products, product durability, and life cycle costs (Article 5, paragraph 11(c)). The regulation further stipulates that the affordability of spare parts must be considered in the development of product-specific requirements (Annex I(b)).

Notably, however, the ESPR does not provide a formal definition of affordability, leaving the operationalisation of this concept to the discretion of those preparing and assessing individual implementing measures. This may constitute a gap in the regulatory framework, as the absence of a standardised metric or threshold risks inconsistent application across product groups and jurisdictions. Nevertheless, it may also provide some pragmatic leeway for policy-makers.

It is also worth noting that energy efficiency requirements established under the ESPR carry an implicit affordability benefit, insofar as they serve to reduce consumer vulnerability to energy price volatility by lowering the volume of energy consumed.

DOI: 10.66506/essp.8-181-26

ECODESIGN DIRECTIVE (2009/125/EC)

The ESPR predecessor Ecodesign Directive (European Parliament and Council of the European Union, 2009), which established the framework for setting ecodesign requirements for energy-related products, contains a comparable affordability provision, stipulating that implementing measures shall produce no significant negative impact on consumers – particularly with respect to the affordability and life cycle cost of the product.

Annex II of the Directive provides more specific methodological guidance, specifying that energy efficiency or consumption requirements must be set with the aim of achieving the minimum life cycle cost to end-users for representative product models, whilst considering consequences for other environmental aspects. This principle was operationalised through the Methodology for Ecodesign of Energy-related Products (MEErP), a techno-economic and environmental assessment framework applied to specific product groups as the principal analytical step in the development of product-specific ecodesign requirements. The MEErP thus provides the analytical foundation for identifying the efficiency level at which the total cost to the consumer – comprising both purchase price and lifetime running costs – is minimised.

UNITED STATES APPLIANCE AND EQUIPMENT ENERGY EFFICIENCY STANDARDS

In the United States, the Appliance and Equipment Standards Program, administered by the Department of Energy (DOE), establishes uniform minimum energy efficiency requirements applicable to all covered products sold on the US market (NAECA, 1987). The programme has delivered substantial energy bill savings for both consumers and businesses, and has been particularly noted for its benefits to renters – a group that typically bears energy costs without having exercised a choice over the appliances installed in their homes. By ensuring that only higher-efficiency products are available on the market, the standards effectively expand access to more affordable-to-operate appliances across all consumer segments.

The rulemaking process is supported by a series of technical supporting documents, which address the following analytical components: market and technology assessment; engineering analysis; life cycle cost and payback period analysis; national impact analysis; and manufacturer impact analysis (US DOE, 2020). This structured analytical framework ensures that efficiency standards are grounded in robust techno-economic evidence prior to adoption.

Economic justification for each standard is assessed against seven statutory factors, which collectively afford the DOE latitude to weigh the relative costs and benefits of alternative efficiency levels. Importantly, this framework permits consideration of distributional disparities in cost–benefit profiles – that is, circumstances in which a particular standard level would impose disproportionate costs on specific consumer groups or other stakeholders relative to the benefits received (US DOE, 2020). This distributional sensitivity is increasingly reflected in DOE analytical practice: in 2024, the DOE published dedicated guidance on distributional equity analysis for energy efficiency and distributed energy resource programmes, providing a methodological framework for assessing the differential impacts of standards across income groups and other socioeconomic dimensions (Woolf et al., 2024). For instance, this equity analysis was used for a representative rulemaking on refrigerators, explicitly citing disproportionate impact on consumer subgroups (US DOE, 2024).

METRICS

DIFFERENT HOUSEHOLD AFFORDABILITY METRICS

A central methodological challenge in assessing appliance affordability is the identification of appropriate indicators or metrics. Affordability metrics are well established in adjacent policy domains – most notably housing, where an expenditure-to-income ratio of 30% is widely employed as a threshold, and energy poverty, where energy costs exceeding 10% of household income are commonly used to identify vulnerable households. Drawing on these precedents, several candidate metrics may be considered for application to appliance affordability:

- **Budget share** refers to the proportion of household income allocated to a specific expenditure category. Analogous to its application in housing and energy poverty assessment, this metric offers a straightforward means of tracking the relative cost

burden of appliance ownership across income groups, though it does not capture ongoing cost burdens or broader financial pressures.

- **Debt-to-income ratio** measures total debt repayments as a share of gross income, and is commonly employed in mortgage underwriting as an indicator of over-indebtedness risk. Its application to appliance affordability may be relevant were consumers finance purchases through credit arrangements.
- **Minimum budget standards** approaches assess whether a household's income is sufficient to afford a given good or service whilst maintaining a minimum acceptable standard of living – typically defined with reference to decent participation in society. Such approaches are particularly useful for identifying households at risk of being unable to access essential appliances (usually lighting, cooling, hygiene equipment like hot water).
- **Price-to-income ratio** is, for individual products, the most straightforward metric: the purchase price of a product expressed as a proportion of household income. Whilst simple to calculate and readily applicable across national contexts, this metric does not capture ongoing affordability or the full cost burden associated with appliance ownership over the product lifetime.
- **Residual income approach** calculates the income remaining after essential expenditures – such as housing and utilities – have been met, and assesses whether this residual is sufficient to cover additional costs. This approach is regarded by some researchers as conceptually superior to budget share methods, as it more accurately reflects actual living costs and the competing financial pressures faced by lower-income households.

The selection of an appropriate metric for affordability of appliances – or combination of metrics – will depend on the specific policy question under consideration, the availability of data, and the income distribution characteristics of the market in question.

SIMPLE AFFORDABILITY METRIC, COUNTRY AVERAGES

As an initial analytical framework, this paper focuses on the residential sectors, and specifically private households, by examining the following parameters in a price-to-income metric:

- the **purchase price** as the primary affordability variable (economic cost), with scope to extend the analysis to include lifetime costs (encompassing purchase price, running costs, and maintenance expenditure); and
- **household disposable income** as the reference measure of financial capacity.

To illustrate this approach at a national scale, fridge-freezers are used as a representative product category. Purchase price data were obtained through web-scraping of online retail platforms, and household disposable income data were sourced from the OECD (OECD, 2025). Figure 4 presents the median, 20th percentile, and 80th percentile online purchase prices for fridge-freezers across a range of countries in 2024, converted to USD for cross-national comparability. For an immediate wealth comparison, a typical income value is also plot on the second y-axis – the Gross disposable income per capita of households.

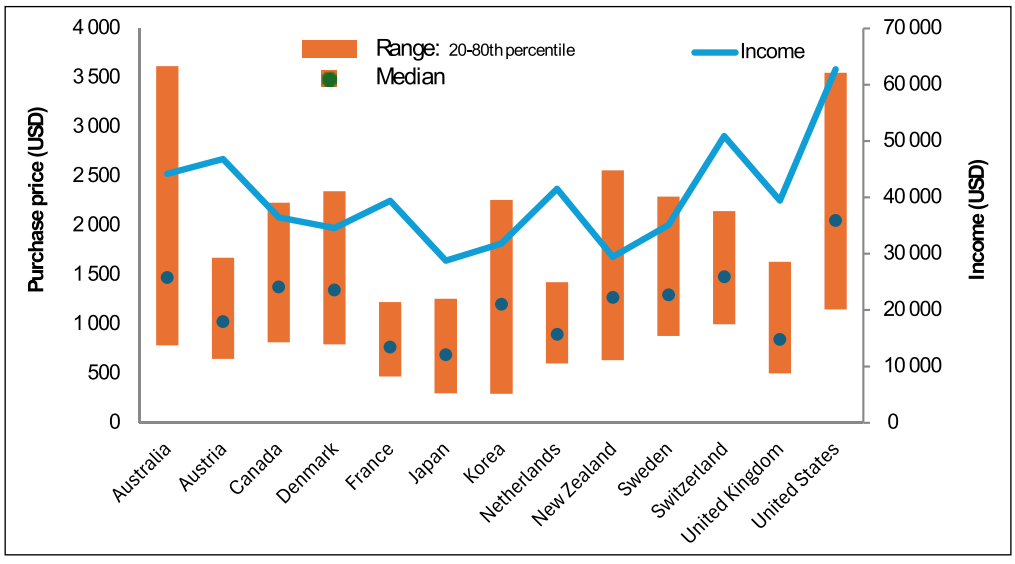

Figure 4 Online purchase price of fridge-freezers, median, 20th and 80th percentiles, and gross disposable income per capita of households (USD), 2024.

DOI: 10.66506/essp.8-181-26

It should be noted that these prices reflect products available through online retail channels and may not be fully representative of the broader market – including in-store purchasing, which may exhibit different price distributions. This limitation should be borne in mind when interpreting the results.

However, at a broad level, purchase prices are generally higher in some markets, such as Australia, Canada and the United States. Unsurprisingly, this is highly correlated with the physical size (and useful freezing/cooling capacity) of such appliances.

Dividing the purchase price by gross disposable income per capita of a household for a specific year can provide a simple affordability index (Figure 5).

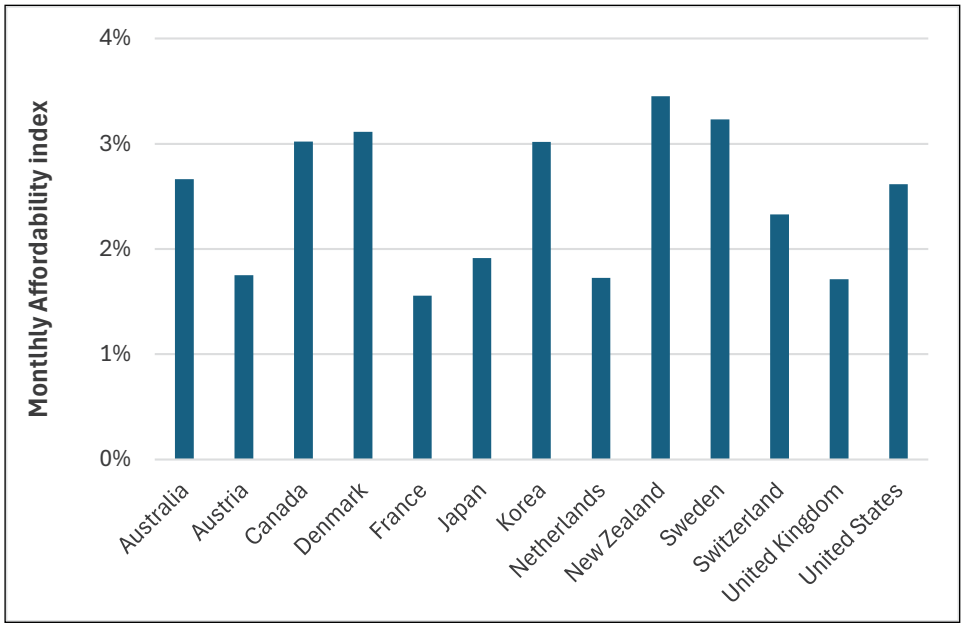

Figure 5 Simple affordability index (purchase price as share of annual disposable income), fridge-freezers, 2024.

This simple metric shows that most households would need to typically spend around 2–3% of their gross disposable income to purchase a fridge-freezer (online).

These can be used over time as a simple indicator, perhaps more meaningful over the long term. For example, a fridge freezer in the United Kingdom in 1980 would have cost around GBP 350, with disposable income around GBP 2,908 at the time, would have meant just over 10% of disposable income was needed for such a purchase. This is five times the proportion today.

To extend the analysis, and as a comparison, it is useful to compare typical running costs within the affordability discussion.

COMPARISON OF LIFE CYCLE COSTS, NATIONAL AVERAGES

Whilst upfront purchase price constitutes the initial cost for most consumers, the life cycle cost (LCC) – comprising purchase price, along with lifetime running costs and maintenance expenditure – provides a more complete picture of the total financial burden associated with appliance ownership. This is of relevance where consumers face a choice between a lower-priced, less efficient product and a higher-priced, more efficient alternative that delivers lower running costs over its operational lifetime.

A national average LCC-based affordability indicator is presented, based on the analytical framework outlined above. The extension of this analysis to incorporate distributional impacts – as demonstrated for fridge-freezers (Figure 6).

Clearly lower priced appliances, coupled with higher efficiency, lower electricity prices, coupled with increased income will increase affordability for all householders.

DISTRIBUTIONAL IMPACT, UK EXAMPLE

Country-level averages, whilst informative, mask significant variation in affordability across the household income distribution. To examine this, a distributional analysis is presented for the United Kingdom, examining the purchase price of a median representative product relative to

DOI: 10.66506/essp.8-181-26

the income distribution of UK households. This approach allows identification of the income thresholds below which appliance purchase may constitute a meaningful financial burden (Figure 7). For this example, although the typical UK household may require around 2% of their gross income to purchase a fridge-freezer, for a low-income home in the poorest decile would require over 6% of their income.

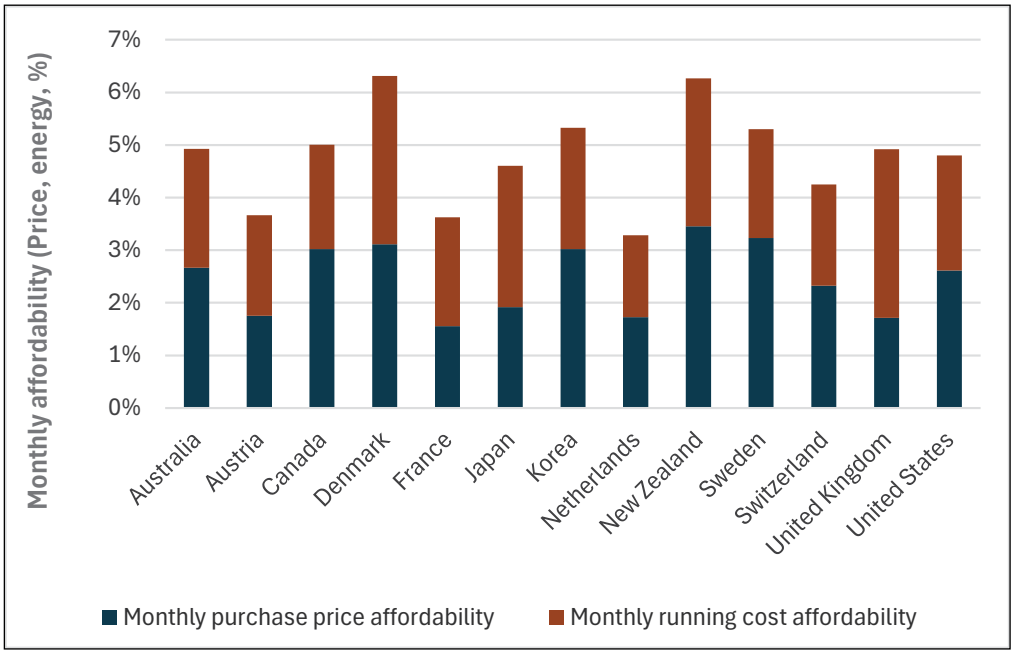

Figure 6 Purchase and LCC affordability index (averaged over lifetime of product), fridge-freezers, 2024 [correction].

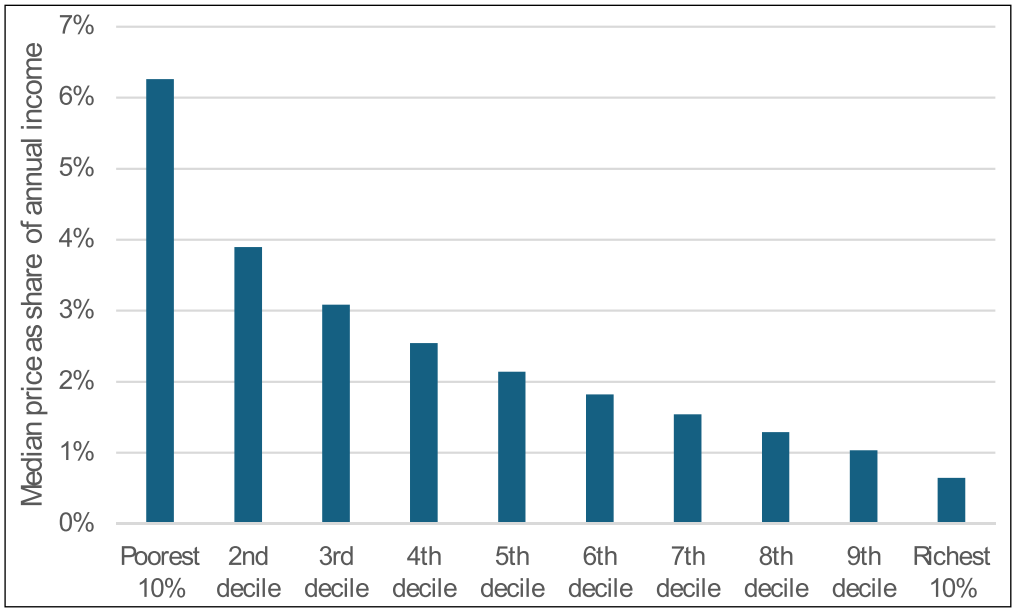

Figure 7 Affordability index, by income decile, UK, fridge-freezer, 2024.

Further development of this analysis – incorporating a wider range of product categories, a fuller characterisation of the income distribution, and longitudinal price data – is identified as an area for subsequent work.

DISTRIBUTIONAL IMPACT, WITH DIFFERENT EFFICIENCY OF PRODUCTS

Although typical values are useful for national level insights, as shown, examining the distribution impact of different levels of efficiency is important. Householder can choose to purchase high or low efficiency products. An example of extending the analysis to show the impact of high/low efficiency on an extended bundle of appliances (i.e. aggregated across several products, in Sub-Saharan Africa) is shown in Figure 8.

This shows that in general more efficient products do cost more to purchase, however, they repay over their lifetime, in all income groups.

DOI: 10.66506/essp.8-181-26

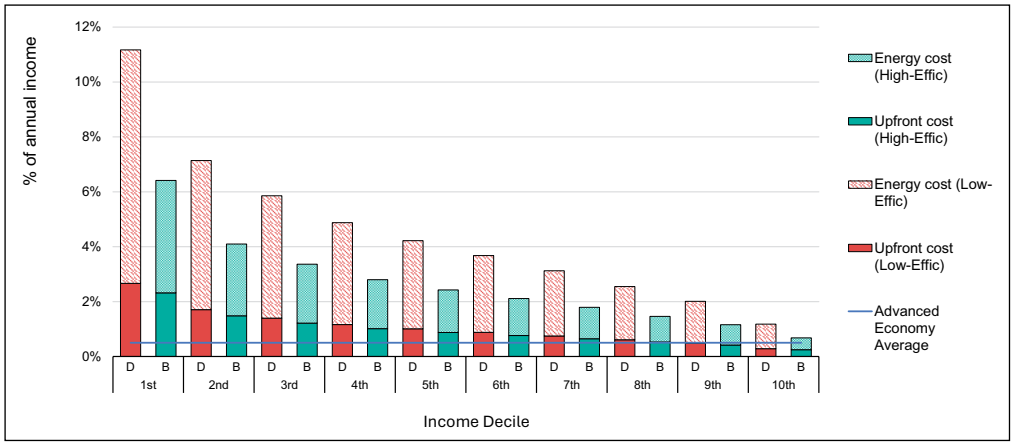

Figure 8 Share of income spent on inefficient and highly efficient extended bundle of appliances, by income decile in sub-Saharan Africa (IEA, 2026).

POLICY CONSIDERATIONS

As demonstrated in the preceding sections, MEPS and energy labelling schemes have proven highly effective instruments for improving the energy efficiency of products. Nevertheless, barriers to consumer uptake of the most efficient available products persist. Key barriers commonly identified in the literature include: (1) higher upfront purchase costs relative to less efficient alternatives; (2) limited access to capital or consumer credit; (3) perceived or actual incremental maintenance costs; and (4) insufficient consumer awareness of efficiency benefits and long-term cost savings. Two questions follow:

- Are there any implication for MEPS and labels?
- What other actions could be considered by governments beyond MEPS and labels?

IMPLICATION FOR MEPS AND LABELS

MEPS remain among the most powerful instruments available to policy makers for driving efficiency improvements, as the evidence above on energy savings and market transformation indicates. When designing or revising MEPS, regulators should consider the distributional implications of proposed standards – that is, the impact on different actors (consumers, industry, government), and especially the cost changes across the household income distribution. Such an assessment ensures that standards do not inadvertently impose disproportionate cost burdens on lower-income households, and importantly can inform the calibration of complementary support measures – such as targeted subsidies, on-bill financing, or social tariffs – rather than weaking of the standard itself. It is also worth noting that, because higher-income consumers typically purchase efficient models first, learning effects and economies of scale tend to bring efficient technologies down the cost curve within a few years, making them progressively affordable across the wider market. Some jurisdictions, notably the United States already consider distributional impacts, especially the first cost on consumers – a key affordability metric.

Additionally, regulators should ensure all products are covered by MEPS, especially those that are used by households with financial constraints or tenants (not purchasing products). For example, some products, such as commercial washing machines are not yet covered by MEPS in the EU.

Where labels are introduced, for example to overcome market failure, any consumer response to these is not mandatory. Thus, there should be no adverse affordability implication for consumers. For categorical labels, the highest category thresholds should be set well above the minimum life cycle cost efficiency level to enable consumers who wish to go beyond economic levels, and provide an incentive for manufacturers to lower costs further for higher efficiency products.

Ultimately, in markets where MEPS are being considered and which may increase purchase prices, policy-makers may consider a range of complementary policy instruments, including targeted financial support mechanisms. These are discussed in the next section.

BEYOND MEPS

Where market barriers persist – particularly for lower-income households – targeted interventions beyond MEPS and labelling may be warranted. Evidence from dedicated programmes for low-income households suggests that direct provision or subsidised replacement of inefficient

appliances can deliver meaningful efficiency and affordability benefits for this group. For example, (Hollander and Roser, 2015) provide relevant evidence in the context of refrigerator replacement programmes for low-income households, demonstrating the potential for targeted schemes to address the efficiency and affordability gap that MEPS alone may not fully close.

Further policy options include targeted rebate schemes for the purchase of high-efficiency appliances; financing mechanisms to address upfront cost barriers (such as on-bill financing); and regulatory attention to currently unregulated product categories and market segments, including those serving social housing and multi-occupancy residential buildings.

Successful examples exist of policies which target low-income and vulnerable households. For example, the Italian Bonus Elettrodomestici 2025 (Bonus Elettrodomestici, 2025) is implemented via a digital voucher issued with a higher value for low-income recipients. Whilst, the long-running German Stromspar-Check (SSC, 2024) is more strongly focussed on low-income, or benefit receiving households, via in-person home visits.

CONCLUSIONS

Household appliances are substantially more affordable today than they were fifty years ago. Furthermore, effective product policy – principally through MEPS and energy labelling – has driven significant improvements in appliance efficiency, reducing both the energy consumption and the operating costs associated with appliance ownership. Importantly, average purchase prices have also declined markedly in real terms over this period, such that purchasing appliances now represents a considerably smaller share of household income than they did one or two generations ago.

Nevertheless, affordability challenges persist for specific consumer groups – particularly lower-income households, renters, and those with limited access to credit – for whom upfront purchase costs may remain a meaningful barrier, even where the long-term financial case for more efficient products is clear. Addressing these distributional dimensions of appliance affordability represents an important and underexplored area for both research and policy development.

FUTURE ANALYSIS

This paper represents an initial contribution to an ongoing research agenda. Priorities for further analysis include:

- extended examination of price data incorporating product features and quality characteristics, to better isolate the efficiency premium within observed price variation;
- examination of products available for sale with high efficiency and low price. Further exploration of the price-vs-efficiency question;
- longitudinal studies, especially the analysis of price effects following the introduction of regulations, to assess the extent to which MEPS and labels have contributed to observed price changes across product categories;
- a parallel study of the how consumers engage with the second-hand market;
- further investigation of how affordability varies across different market segments and consumer groups; and
- deeper analysis of consumer behaviour in response to efficiency standards and labelling, including the role of information, trust, and financial constraints in shaping purchasing decisions.

ADDITIONAL FILE

The additional file for this article can be found as follows:

- **PowerPoint Slides.** PowerPoint Slides relating to this article. DOI: https://doi.org/10.66506/essp.8-181-26.s1

ACKNOWLEDGEMENTS

This paper is based on ongoing work being undertaken by the IEA Technology Collaboration Programme on Energy Efficient End-use Equipment (4E TCP). The authors would especially like to thank Jan Viegand for undertaking an initial scoping study for the 4E TCP on the topic of Affordability and appliances, and the anonymous reviewers for providing insightful comment. The authors have made their best endeavours to ensure the accuracy and reliability of the data presented herein, however neither they, the countries sponsoring the research, nor the IEA or the 4E TCP or its member countries make any warranties as to the accuracy of data herein, nor accept any liability for any action taken or decision made based on the contents of this paper.

COMPETING INTERESTS

The authors have no competing interests to declare.

ECEEE PAPER ID

8-181-26

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TO CITE THIS ARTICLE:
Lane, K, Díaz, A and Attali, S. 2026. Affordability of energy efficient appliances – indicators and evidence. *eceee Summer Study proceedings*, 1(1): 38, pp. 1–14. DOI: https://doi.org/10.66506/essp.8-181-26

Submitted: 25 March 2026
Accepted: 15 May 2026
Published: 07 August 2026