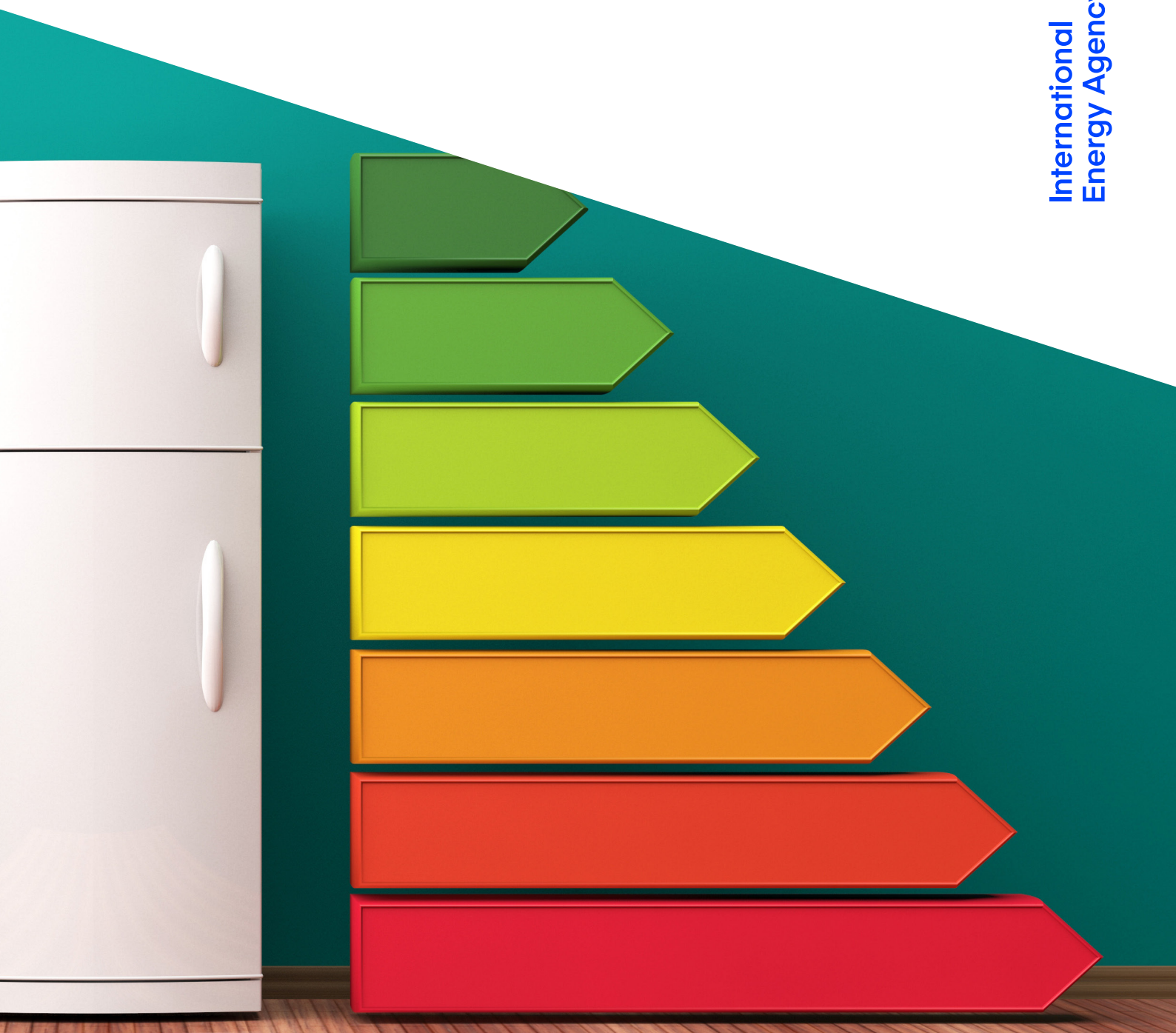
# Achievements of Energy Efficiency Appliance and Equipment Standards and Labelling Programmes

International Energy Agency



# Achievements of Energy Efficiency Appliance and Equipment Standards and Labelling Programmes

International Energy Agency

# INTERNATIONAL ENERGY AGENCY

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 30 member countries, 8 association countries and beyond.



**IEA member countries:**

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA

**IEA association countries:**

Brazil
China
India
Indonesia
Morocco
Singapore
South Africa
Thailand

# Abstract

This summary report provides an overview of the impact that standards and labelling programmes are having on the energy efficiency of energy-using appliances and equipment in countries around the world. It draws on a global review of nearly 400 published reports, studies and papers covering more than 100 products – representing one of the most comprehensive datasets assembled on the topic to date. It confirms that improvements to the energy efficiency of appliances and equipment are some of the lowest-cost options available today for reducing energy consumption and associated emissions, with typical society benefit/cost ratios of 4:1. Programmes that have been operating the longest, such as those in the United States and the European Union, are estimated to deliver annual reductions of around 15% of total current electricity consumption. These programmes provide net financial benefits to individuals and the community. Other benefits, including employment, product innovation, water savings, improvements in air quality and the reduction of public expenditure on health, add to the case for stronger standards and labels.

# Acknowledgements

This summary report is based on a study commissioned by the International Energy Agency (IEA) Technology Collaboration Programme (TCP) on Energy Efficient End-Use Equipment (4E) in collaboration with the IEA, and made possible through funding from the Swedish and United Kingdom governments. The full report is available from the 4E website here: www.iea-4e.org/publications. Thanks go to the authors of the full report: Lloyd Harrington, Paul Waide, Fiona Brocklehurst and staff at CLASP.

The co-ordinators and lead authors at the IEA were Kevin Lane, Nicholas Howarth and Melanie Slade, with further contributions by Alyssa Fischer and Clara Camasara, and guidance and comments from Brian Motherway.

Mark Ellis was lead author and co-ordinator for the 4E TCP with input and guidance from Peter Bennich (Sweden) and Suleiman Faruqi (United Kingdom).

We are also grateful to the IEA Communications and Digital Office (CDO) and the following CDO colleagues for producing the online draft: Astrid Dumond, Therese Walsh, Isabelle Nonain-Semelin, Mariam Aliabadi and Erin Crum for editing.

**Energy Efficient End-use Equipment TCP**

The Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E TCP), has been supporting governments to co-ordinate effective energy efficiency policies since 2008.

Fourteen countries and one region have joined together under the 4E TCP platform to exchange technical and policy information focused on increasing the production and trade in efficient end-use equipment. However the 4E TCP is more than a forum for sharing information: it pools resources and expertise on a wide a range of projects designed to meet the policy needs of participating governments. Members of 4E find this an efficient use of scarce funds, which results in outcomes that are far more comprehensive and authoritative than can be achieved by individual jurisdictions. The 4E TCP is established under the auspices of the International Energy Agency (IEA) as a functionally and legally autonomous body.

Current members of 4E TCP are: Australia, Austria, Canada, the People's Republic of China (hereafter, "China"), Denmark, European Commission France, Japan, Korea, Netherlands, New Zealand, Switzerland, Sweden, United Kingdom and United States.

Further information on the 4E TCP is available from: http://www.iea-4e.org.

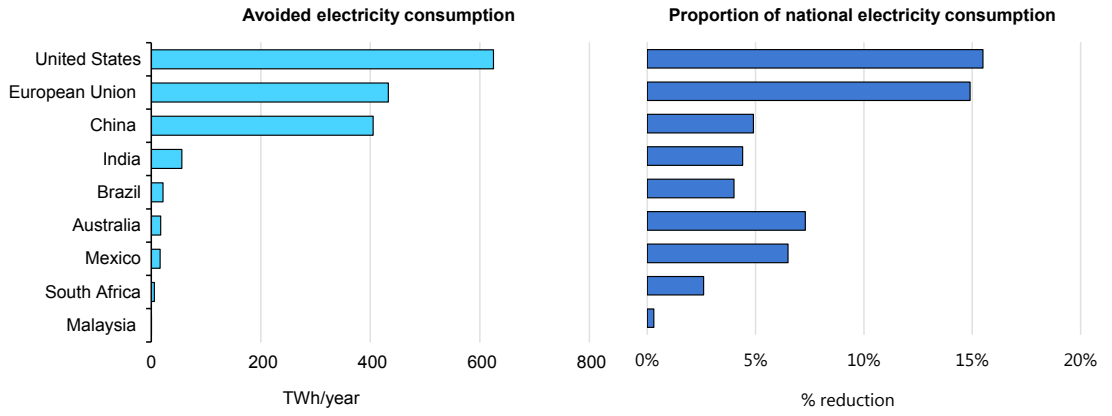
# Executive summary

## Best-practice standards and labels are delivering a 15% reduction in national electricity consumption

More and more countries are recognising the many benefits of energy efficiency standards and labelling (EES&L) programmes to effectively reduce energy bills, drive product innovation, create jobs and reduce $CO_2$ emissions cost. EES&L programmes for appliances and equipment now operate in more than 120 countries around the world and provide the cornerstone of most national energy efficiency and climate change mitigation programmes.

In the nine countries for which data were available, EES&L programmes reduced the annual electricity consumption by around 1 580 TWh in 2018. This is a similar order of magnitude as the total electricity generation of wind and solar energy in those countries in 2018.

**Figure ES.1 Annual reduction in electricity consumption from standards and labelling programmes**




IEA and 4E TCP.

Notes: Some national EES&L programmes also cover other fuel types, such as gas appliances. Savings from these products are additional to those shown here. European Union includes the United Kingdom, as it was a member when the analysis was undertaken.

The EES&L programmes that have been operating the longest, such as those in the United States (US) and the European Union, are estimated to deliver annual reductions of around 15% of total current electricity consumption. This percentage increases each year as more of the older, less-efficient stock is replaced with equipment that meets new higher efficiency standards.

If a similar 15% improvement had been achieved by all countries, a reduction of current electricity consumption in the order of 3 500 TWh

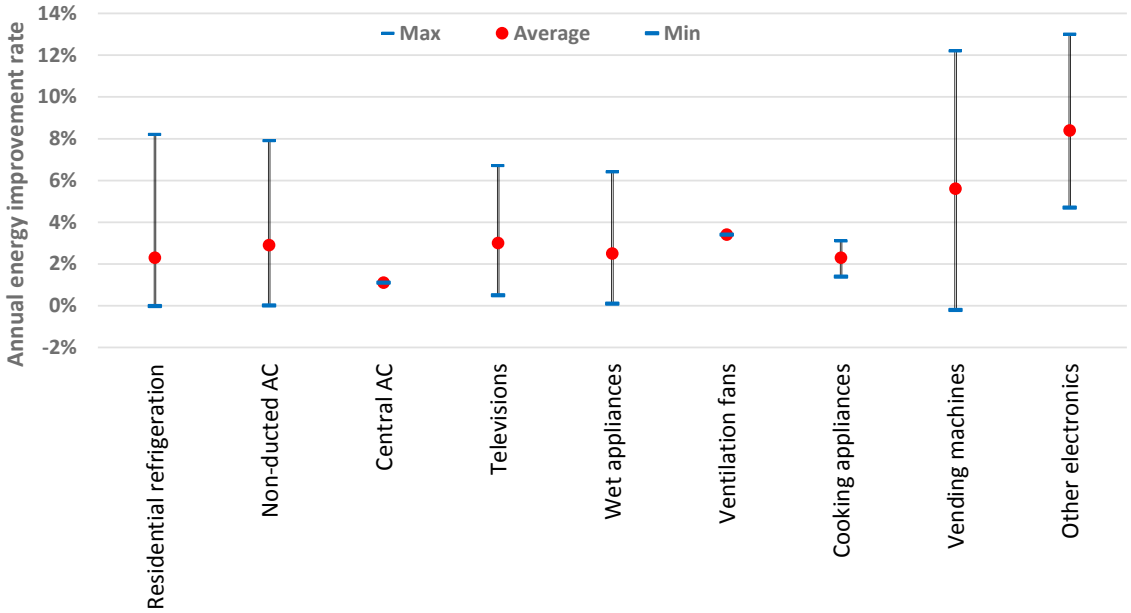
per year could have been achieved in 2020 – roughly equivalent to cutting China's current total electricity consumption in half.

EES&Ls also cover gas- and oil-powered water and space heating. Including these end uses in some countries can increase the avoided energy consumption attributable to EES&L programmes by a factor of three. For example, in the European Union, 1 777 TWh or 15.3% of total primary energy consumption was saved in 2020.

## EES&Ls can lift the average rate of energy efficiency improvement in new appliances by two to three times

Based on global evidence from countries with EES&L programmes, the average energy efficiency of new major appliances in these countries has increased two to three times the underlying rate of technology improvement. This has resulted in average energy reductions of 10-30% over 15 to 20 years in the stock of most regulated products across all countries. In leading countries with strong regulations and long-running programmes which are regularly updated, the contribution was much higher, with EES&L programmes helping reduce the electricity consumption of many appliances by over 50%.

**Figure ES.2 Annual energy reduction in new-product energy consumption from EES&L programmes**



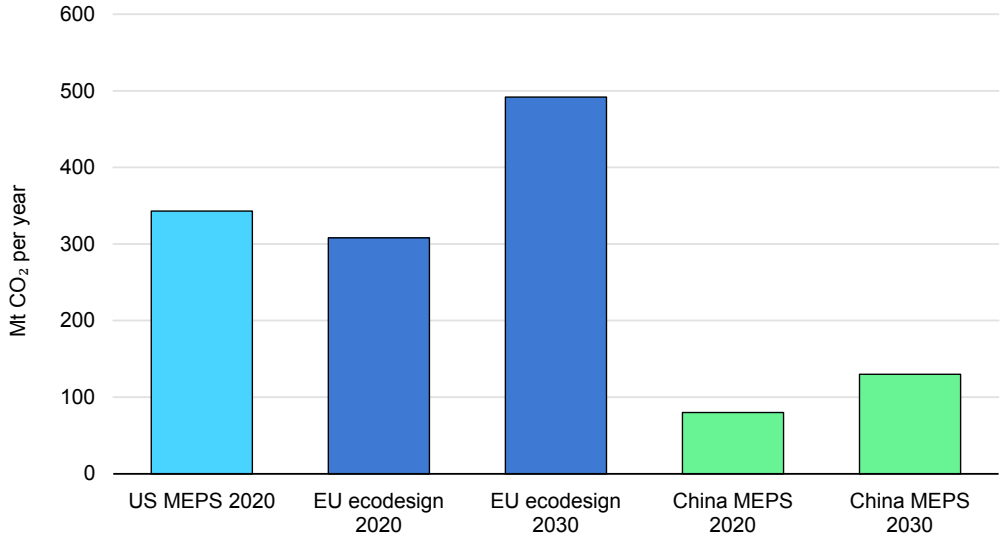

IEA and 4E TCP.

Notes: AC = air conditioning. *Wet appliances* is the category including washing machines, dryers and dishwashers. *Domestic cold* refers to refrigerators and freezers. Percentage improvements are calculated from a baseline which takes into account the autonomous rate of improvement in energy efficiency and separates out the specific impact of the EES&L programme. More categories are covered in the reviews of product efficiency of stock energy performance.

# Best-practice standards and labels contribute 7-10% of total national energy-related $CO_2$ reductions

For countries with the most advanced EES&L programmes, such programmes currently contribute around 7-10% of total energy-related emissions reductions each year. This amounts to around 343 Mt $CO_2$ of avoided emissions in the United States and 311 Mt $CO_2$ in the European Union.

**Figure ES.3 Annual carbon emissions avoided due to standards and labelling programmes**



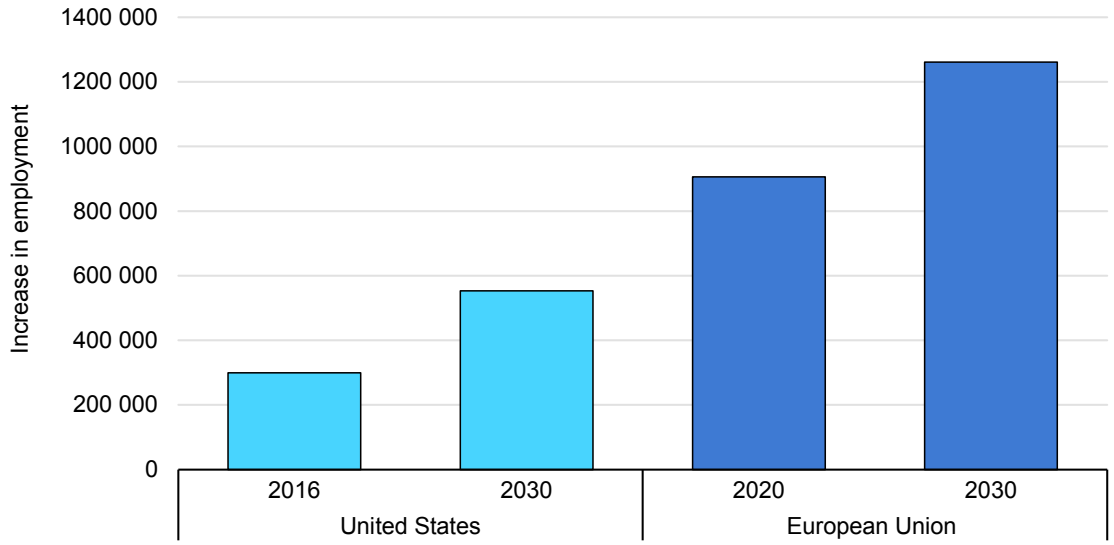

IEA and 4E TCP.

Note: MEPS = minimum energy performance standards.

# Fostering new employment opportunities

EES&L programmes have stimulated economic activity by fostering innovation among manufacturers and creating new job opportunities in wholesale, retail and maintenance. Although challenging to estimate, this has been done for several programmes and economies. For example, in Europe the EES&L programme generates around 1 million direct jobs per year, with one extra job created for every EUR 80 000 spent on more efficient equipment. In the United States, the EES&L programmes generate around 300 000 extra jobs per year. Once the indirect effect of higher consumer spending from lower energy bills and higher disposable income is factored in, the resulting number of jobs created is even more significant.

**Figure ES.4 Direct employment effects of standards and labelling programmes**

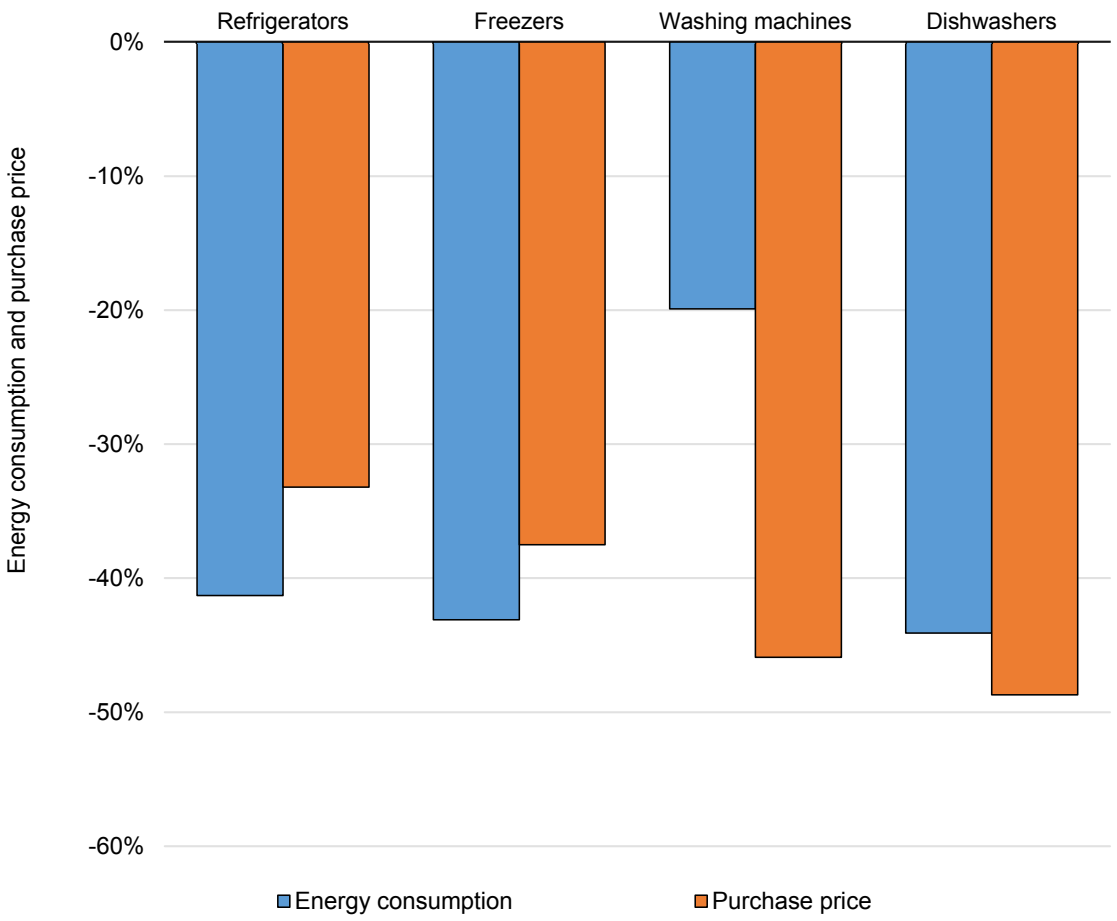



IEA and 4E TCP.

## Appliance prices have come down with improving energy performance

This report also highlights the power of EES&L programmes to drive innovation and help bring down product purchase prices at the same time as reducing their energy consumption. For example, while more efficient appliances are sometimes more expensive to buy when they are first introduced, the average purchase price of appliances covered by EES&L programmes declined at a rate of 2-3% per year. This highlights how manufacturers are able to quickly adapt to meet new efficiency standards. As a result, governments typically overestimate the likely cost impact of proposed future MEPS on product purchase prices by a substantial margin, suggesting that more stringent MEPS levels could have been chosen.

**Figure ES.5 Changes in residential appliance prices and energy performance in Australia, 1993-2014**

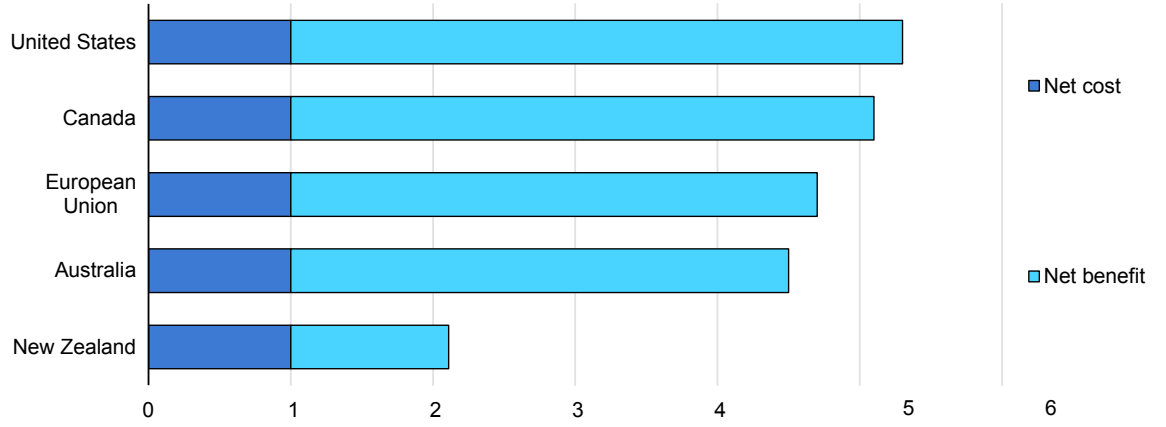



IEA and 4E TCP.

## Benefits of standards and labelling programmes exceed their costs by a ratio of four to one

In all of the EES&L programmes reviewed, cost/benefit studies show that the financial benefits flowing from reduced energy consumption and lower bills outweigh the additional costs from purchasing more efficient equipment and administering the programmes. For example, the US EES&L programme provides net savings of around USD 40 billion per annum to households and businesses, and the average US annual household fuel bill has been cut by USD 320.

**Figure ES.6 Benefit/cost ratio for standards and labelling programmes**




IEA and 4E TCP.

## Standards and labelling programmes to play a key role in helping governments meet their net zero $CO_2$ goals

This report supports work being delivered through the 26th Conference of the Parties (COP26) in November 2021, where the United Kingdom, as COP President, along with the International Energy Agency aim to co-ordinate global action to significantly raise the efficiency of four key products sold globally by 2030. The Call to Action is being driven through the Super-efficient Equipment and Appliances Deployment (SEAD) Initiative. SEAD and 4E provide platforms for international collaboration to implement best practices and increase ambition, which are key to extending the benefits identified in this report and making efficient appliances and equipment available to all.

Research and development activities undertaken by 4E help to inform government policies and support the Call to Action put forth by SEAD. Moving toward 2030, 4E will continue to move the needle forward to raising the efficiency of products sold globally by 2030 by working collaboratively with member countries and SEAD in order to help governments meet their net zero $CO_2$ goals.

# Introduction

Energy efficiency will play a significant role in helping the world achieve Paris climate targets and realise the United Nation's Sustainable Development Goals. Within that, energy efficiency standards and labelling (EES&L) programmes will be key to deliver improved efficiency.

National EES&L programmes have been in existence since the 1970s and have since proliferated. As of 2021, EES&L programmes operate in more than 120 countries around the world and apply to more than 100 types of appliances and equipment in the commercial, industrial and residential sectors. While the design and coverage of EES&L programmes vary according to national circumstances, they provide the cornerstone of most national energy and climate change mitigation programmes.

Typically, EES&L programmes use one or both of the following complementary tools as the basis to improve the energy efficiency performance of appliances and equipment:

- minimum energy performance standards (MEPS), which are employed to overcome barriers to improved efficiency – such as potentially higher purchase prices - and provide a level playing field in competitive markets by prohibiting the least efficient products
- energy labels, which are used to address information barriers and enable consumers to make more informed choices at the point of purchase, either by showing the comparative performance of all appliances (known as rating labels) or by identifying the best-in-class products (endorsement labels)

These two measures may be complemented by other policy measures, such as subsidies and rebates to help transform markets.

While EES&L programmes can make up a substantial proportion of nationally determined contributions (NDCs), the current focus for many countries is on Covid-19 recovery policies. In this context, EES&L programmes also provide a mechanism to kick-start economic recovery while at the same time reaping a range of wider benefits, as catalogued in this study.

Stimulus funding, in particular, provides a unique opportunity to boost energy efficiency as part of the evolving energy system. In all countries, the demand side of energy systems is becoming increasingly important as a greater share of

variable renewables are connected to grids. Efficient end-use technologies lower overall system size requirements and hence grid investment needs and technologies that modulate energy use offer the possibility of improving both end-use and system efficiency.

As governments consider how best to take advantage of untapped energy efficiency resources to meet increasing demand for cleaner energy, this report provides evidence of the benefits of one of the most widespread and longest-running energy efficiency policy mechanisms available.

This summary report draws on nearly 400 documents that provide evidence of the impacts of EES&L programmes and covers more than 100 different product types (see Attachment A for more information on the methodology). It provides an update to a previous review of evidence in 2015 and 2016, undertaken by the International Energy Agency (IEA) Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E), that analysed the achievements of government EES&L programmes for appliances and equipment.

The analysis highlights the following recorded impacts resulting from EES&L programmes:

- overall energy system energy savings and related reductions in $CO_2$ emissions
- overall net costs and benefits of EES&L programmes, including job creation
- energy efficiency improvements for key appliances and products
- driving innovation and bringing down appliance costs
- water savings and health benefits.

# Overall energy system and $CO_2$ impacts

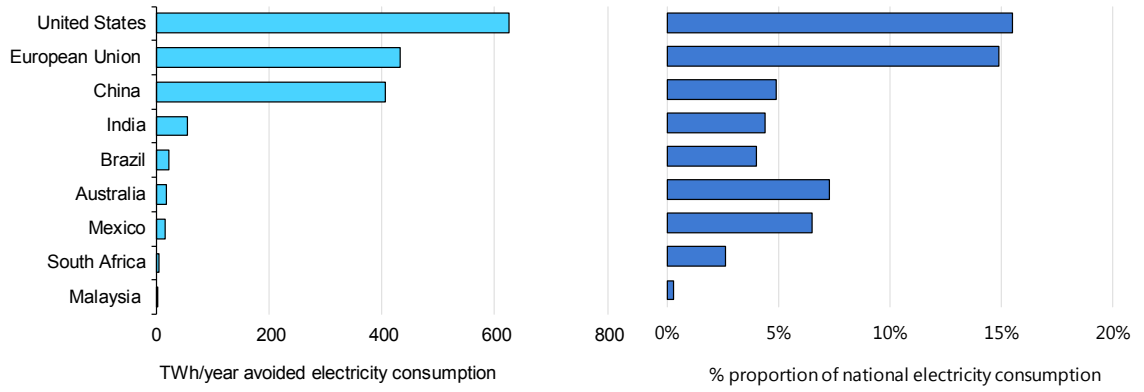
The longest-running EES&L programmes with the largest product coverage have saved approximately 15% of their country's total electricity consumption. Around two-thirds of these savings are seen in the residential sector, while savings in the services and industrial sectors each account for one-sixth of the total.

The nine economies shown in Figure 1 together saved at least 1 580 TWh in 2018. This is a similar order of magnitude to the total electricity generation of wind and solar energy in those countries, which was 1 626 TWh in the same year. This suggests that global savings of around 3 500 TWh could have been realised in 2020 if all countries adopted similar measures, roughly equivalent to halving the total electricity consumption of China.

Under these programmes, new, more efficient products are continually entering the market and replacing older, less efficient ones, compounding the energy savings year after year as the overall stock of appliances becomes more efficient. For example, the savings achieved by the current EES&L programmes in the European Union (EU) is forecast to increase from 14.9% of total EU electricity consumption in 2020 to 24.1% by 2030.

This means that longer-running programmes show greater levels of savings, partly because sufficient time has elapsed for regulated products to represent a larger share of the overall appliance stock in use. These more mature programmes also tend to cover a wider variety of products and have increased their levels of stringency over time, which increases the energy savings they deliver. In the case of the United States (US), the EES&L programme has achieved a reduction of 15.5% of total electricity consumption savings while newer and less extensive programmes in other countries have not yet reached this level.

**Figure 1 EES&L programme-related annual electricity savings, 2018**




IEA and 4E TCP.

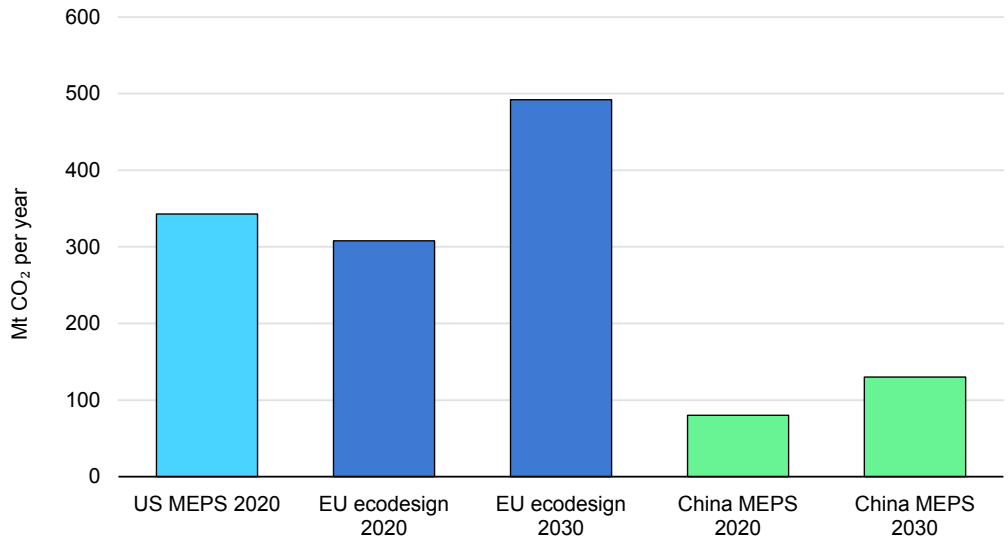
Notes: Some national EES&L programmes also cover other fuel types, such as gas appliances. Savings from these products are additional to those shown here. European Union includes the United Kingdom, as it was a member when the analysis was undertaken.

EES&L programmes also can extend beyond electricity to cover oil- and gas-powered space and water heating. In Europe, for example, including these end uses raises the total energy savings from EES&L programmes to 1 777 TWh or 15.3% of total primary energy consumption in 2020.

Because fossil fuels still dominate the energy mix, energy savings through EES&L programmes also lead to substantial $CO_2$ reductions (Figure 2), making the recorded greenhouse gas emission impacts attributable to EES&L programmes equally impressive. In the United States, MEPS avoided 343 Mt $CO_2$ in 2020, equivalent to 7.1% of all national energy-related emissions for 2019.

The EU EES&L programme – ecodesign and mandatory labelling – has had a similar impact, cutting emissions by 311 Mt $CO_2$, or 10.7% of the European Union's total energy-related emissions for 2019. This is 7% of total EU $CO_2$ equivalent emissions from all sources in 2018. By 2030 the impact of current policy measures will accumulate to 498 Mt $CO_2$ or 12% of the EU 2018 total for all sources.

**Figure 2 Annual $CO_2$ emissions reductions from standards and labelling programmes**

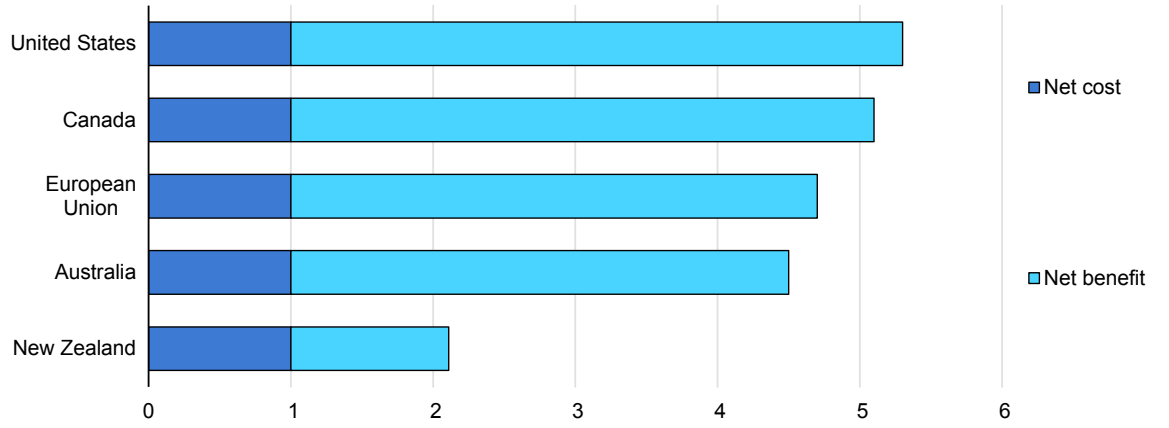



IEA and 4E TCP.

# Impact of EES&L programmes on costs, employment and household incomes

EES&L programmes are highly cost-effective, with energy cost savings often many times larger than any increases in the cost of purchasing products or administering the programme. This is demonstrated in Figure 3, which shows the overall net benefit-to-cost ratios for EES&L programmes in several major economies.

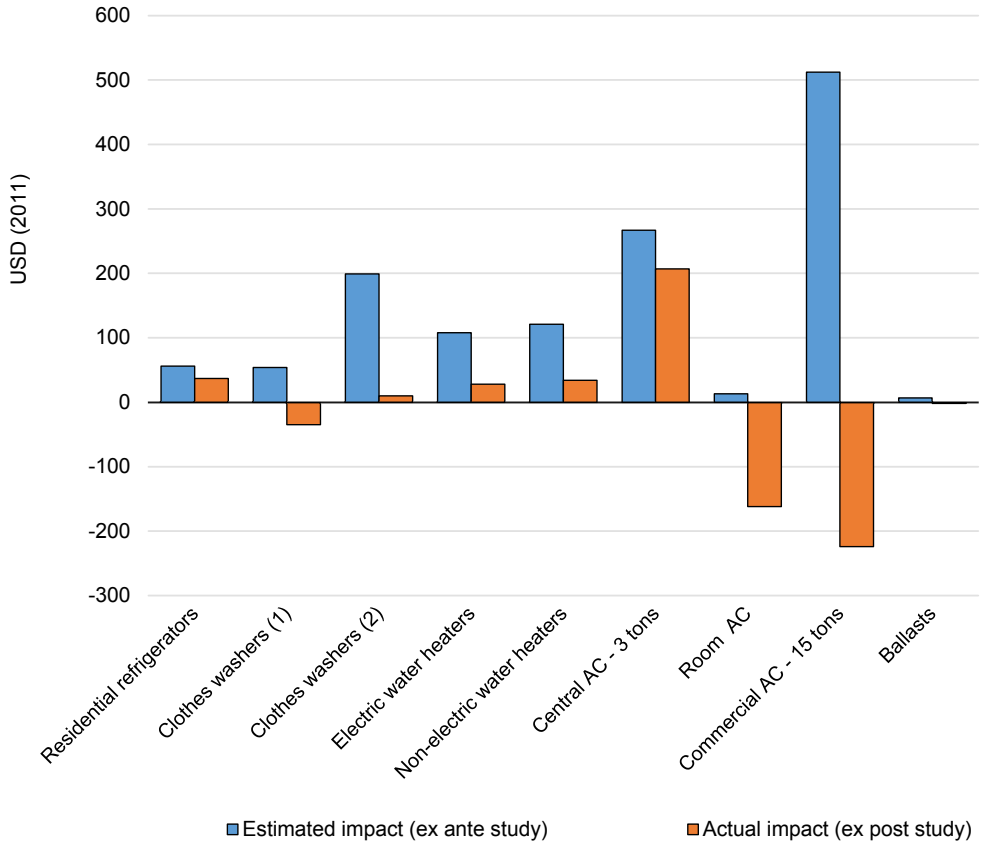
**Figure 3 Benefit/cost ratio for MEPS and labelling programmes**




IEA and 4E TCP.

This is no accident, as most governments demand that new regulatory measures pass strict net-benefit tests before they can be adopted. However, in many cases regulators have overestimated the costs of meeting efficiency requirements, since retrospective analysis consistently shows that innovation and “learning by doing” reduces the impact on product prices (Figure 4). In fact, most products in countries with EES&L programmes have become both more efficient and cheaper over the duration of these programmes. Falling consumer purchase prices suggest that more stringent policy settings still deliver net consumer benefits.

**Figure 4 Comparison of predicted and actual price increases from US MEPS**

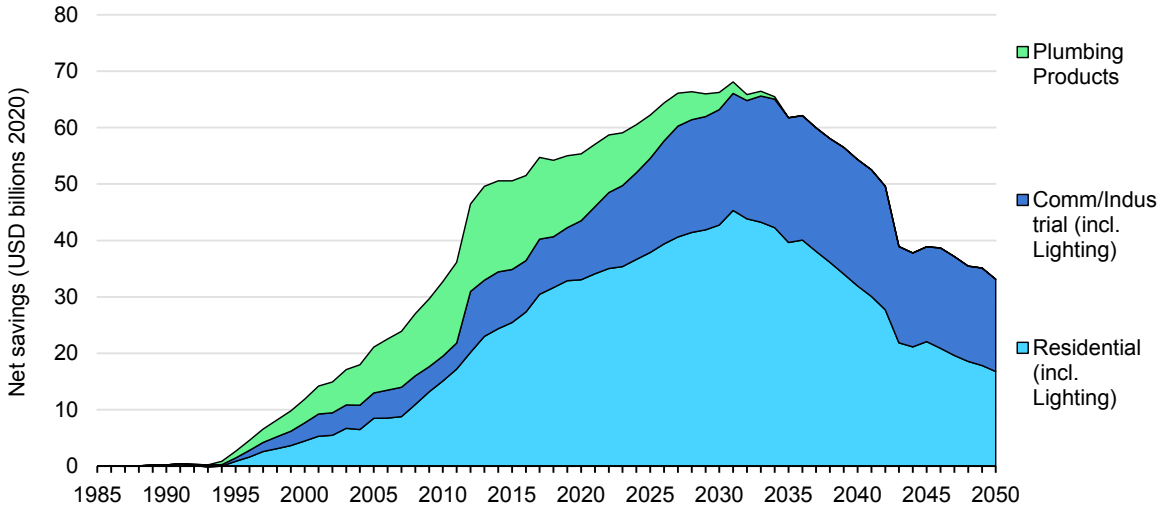



IEA and 4E TCP.

Note: AC = air conditioning.

Not only are EES&L programmes highly cost-effective, but they deliver very large savings for households and businesses. In the United States, EES&L programmes delivered annual fuel cost savings of USD 40 billion in 2020 (Figure 5), resulting in an annual reduction in the average US household energy bill of around USD 320.

**Figure 5 Annual undiscounted net consumer benefit by year for US MEPS by sector**




IEA and 4E TCP.

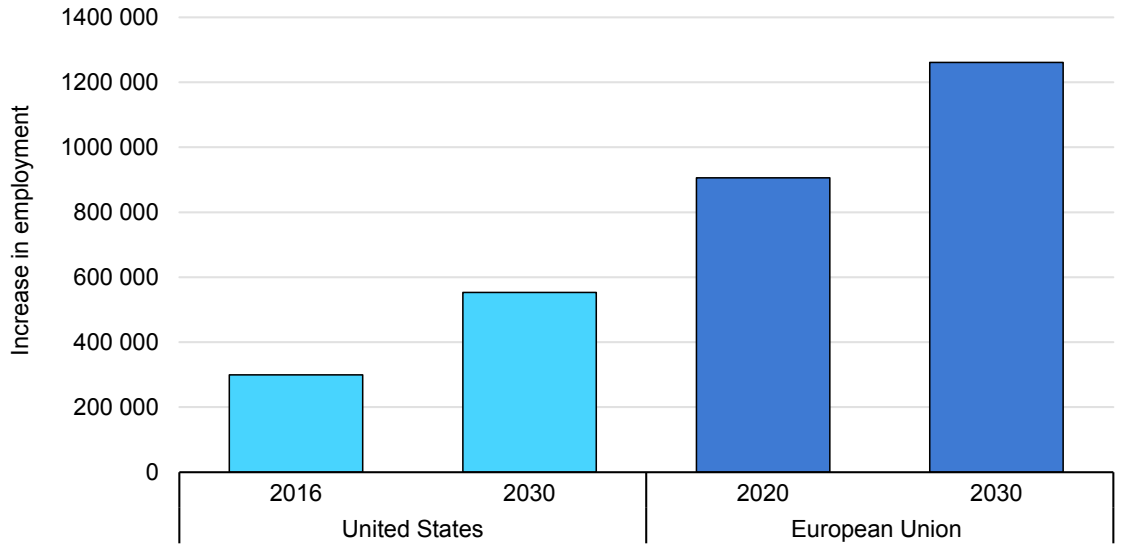
Source: Energy and Economic Impacts of U.S. Federal Energy and Water Conservation Standards Adopted from 1987 through 2013. Updated 2021.

This survey of available evidence confirms that EES&L programmes are one of the lowest-cost policies available to reduce $CO_2$ emissions. Since EES&L programmes generate net benefits to individuals and to society, they deliver $CO_2$ savings at "negative cost" in most representations of $CO_2$ marginal abatement cost curves.

EES&L programmes also directly create jobs in manufacturing, wholesale, retail and maintenance, and indirectly through the spending of fuel cost savings in the local economy (Figure 6). Although challenging to estimate this impact, figures have been estimated for some economies. For example, the EU EES&L programme was estimated to have directly created 906 000 jobs in 2020, a figure expected to rise to over 1.2 million annually by 2030. While direct job creation is significant, the creation of indirect jobs can be three to five times larger, as evidenced in the European Union.

Different national contexts regarding local manufacturing, industrial structure, the cost of labour and the degree to which expenditure in the economy at large will generate indirect jobs mean it can be difficult to transfer results from one country to another. This may explain why a study of the US EES&L programme estimates are lower but still significant, with the creation of 299 000 direct and indirect jobs in 2016, rising to 553 000 in 2030.

**Figure 6 Direct employment effects of EES&L programmes**




IEA and 4E TCP.

In Australia, an estimated 59 000 to 236 000 people work in roles related to the energy efficiency of residential and commercial buildings. This is significantly more people than are employed in coal mining and electricity networks. It is estimated that new appliances and equipment upgrades in Australia could create an additional 40 000 jobs per year.

In all countries, the potential to replace jobs in fossil fuel sectors, such as coal, with energy efficiency jobs offers an important pathway in ensuring a more people-centred energy transition. Various additional policy and programme approaches will be required, such as support for reskilling, to stimulate this transition.

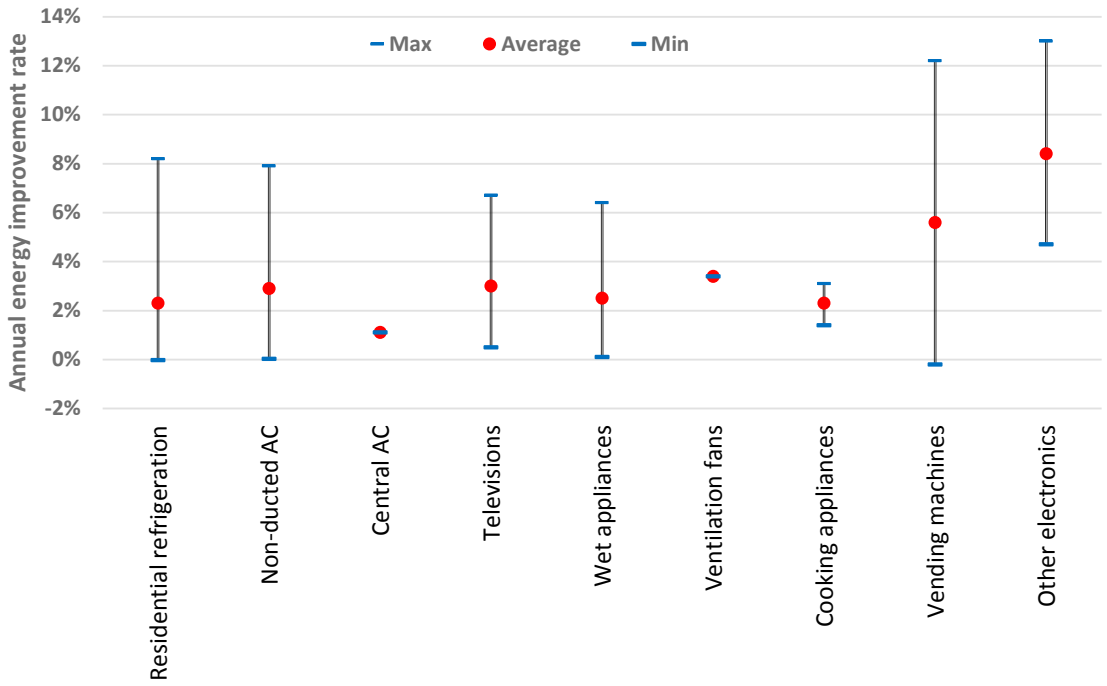
# Impact of EES&L programmes on the energy consumption of key appliances

EES&L programmes typically reduce the average energy consumption of most new products around two to three times faster than similar products not covered by such programmes. The average rate of improvement varies for different products, as shown in Figure 7. For products such as refrigerators and especially televisions, the increasing popularity of larger models has reduced the observed rate of improvement.

Average annual improvement rates for new appliances' energy consumption are primarily determined by the stringency of policy settings within EES&L programmes and the frequency at which they are updated. These vary over time and between economies, which explains the ranges shown in Figure 7. The countries with the longest-running programmes and the most stringent standards, such as the United States, the European Union and Japan, are at the top of these ranges. The countries with more recent assessment periods and programmes or where standards are not as strict are towards the lower end of the ranges.

For example, the energy consumption from average new residential refrigerators and freezers fell by around 2.3% per year across all countries. The best-performing countries with the most advanced programmes recorded improvement rates of up to 8% per year. The improvement rate represents the average energy reduction each year of that appliance type based on the specific impact of EESS&L programmes. Other changes, such as autonomous rates of improvement, are excluded.

**Figure 7 Annual average reduction in new-product energy consumption from EES&L programmes**

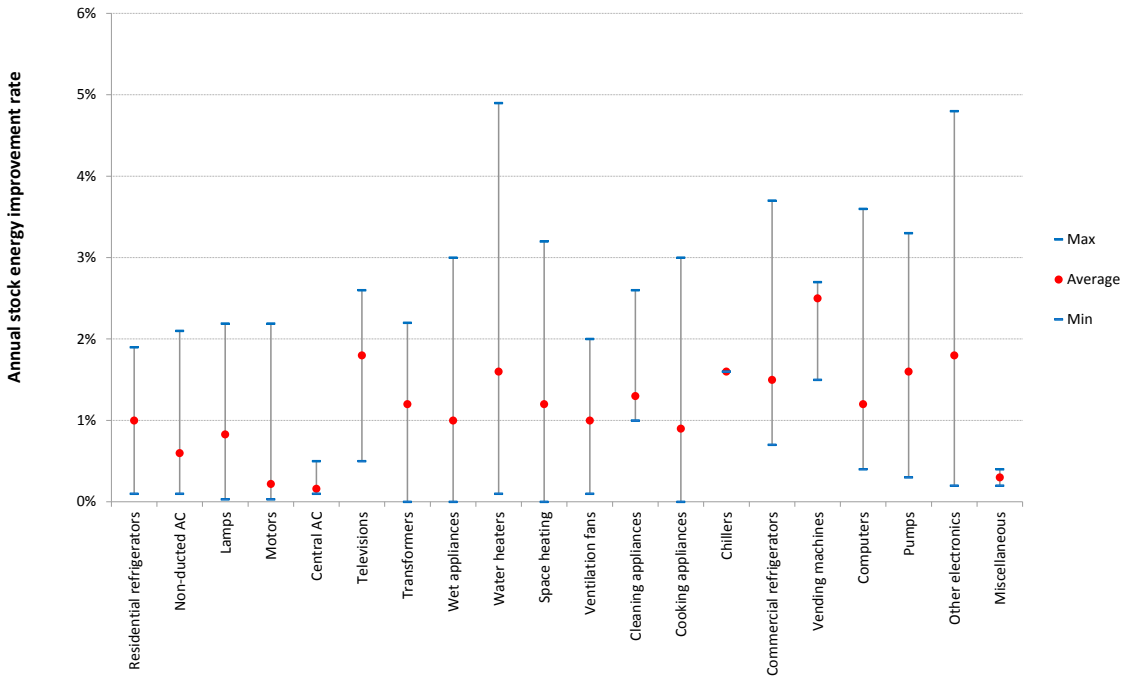



IEA and 4E TCP.

Notes: AC = air conditioning. *Wet appliances* is the category including washing machines, dryers and dishwashers. *Domestic cold* refers to refrigerators and freezers. Percentage improvements are calculated from a baseline which takes into account the autonomous rate of improvement in energy efficiency and separates out the specific impact of the EES&L programme. More categories are covered in the reviews of product efficiency of stock energy performance.

EES&L programmes set the bar for new products entering the market, raising the average efficiency of all products in use over time. The impact of EES&L programmes on the annual rate of improvement by type of product is shown in Figure 8. Since it takes time to replace old, inefficient units with new, more efficient ones, the annual rate of improvement across the entire stock always lags behind the improvement rate of new appliances.

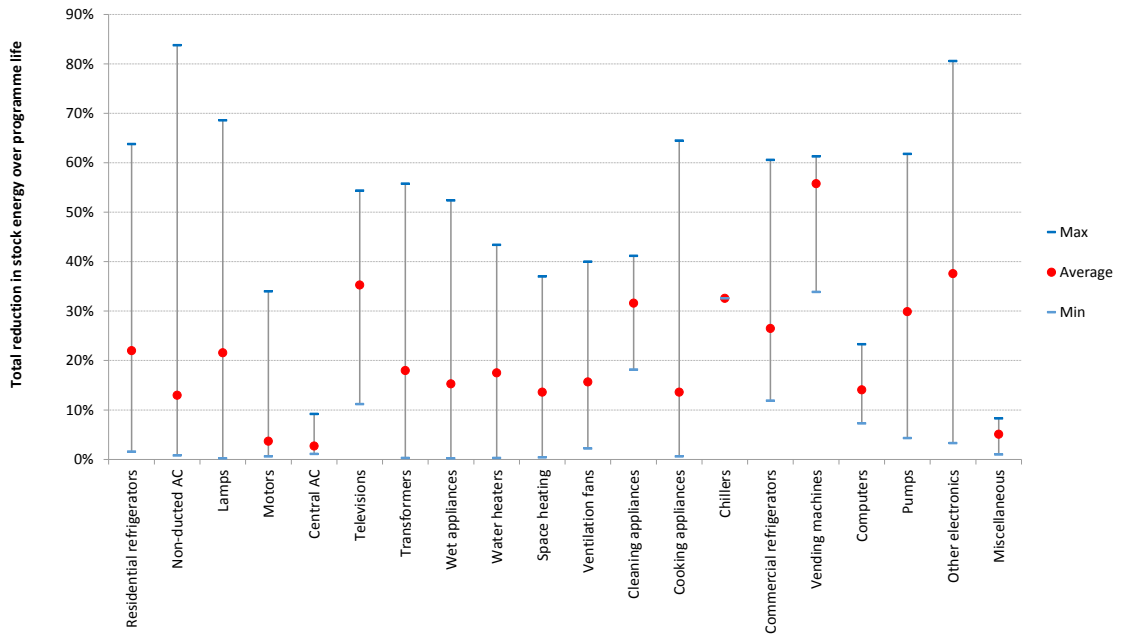
**Figure 8 Annual reduction in stock average energy consumption from EES&L programmes**




IEA and 4E TCP.

Figure 9 shows the overall energy reductions achieved by EES&L programmes over the life of the entire programme. This shows that average energy reductions between 10% and 30% have been achieved over moderate time frames for the stock of most regulated products. The savings are determined using a baseline without the EES&L programmes. For example, the average reduction in the energy consumption of the stock of domestic cold appliances was around 22% and ranged up to 64% for the more mature programmes. These energy performance improvements have enabled the number and size of refrigerators to grow without significantly increasing overall national energy consumption, and in some cases, helped decrease overall energy consumption. Without these energy efficiency improvements, energy consumption from refrigerators and freezers would have been up to almost three times higher in some markets.

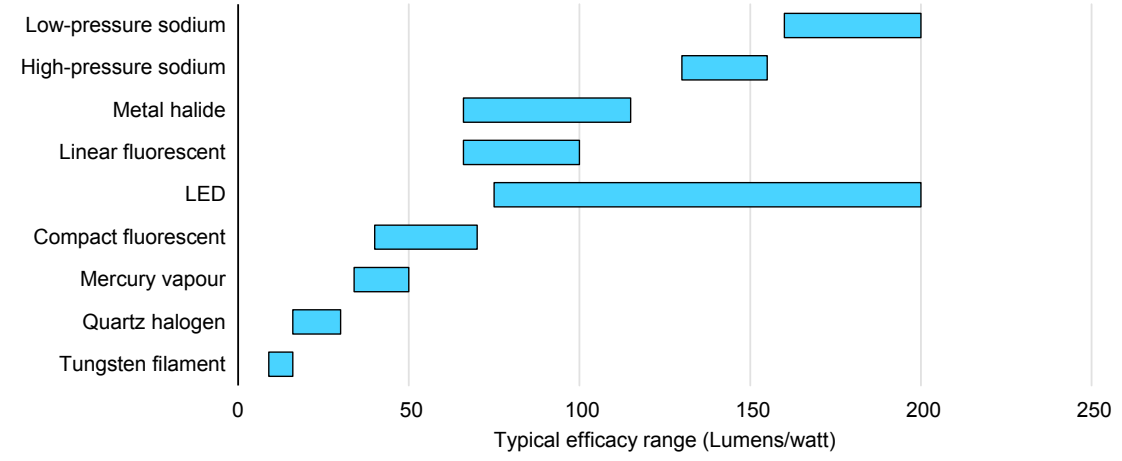
**Figure 9 Appliance energy savings from EES&L programmes over life of programmes**




IEA and 4E TCP.

Countries that have relatively new EES&L programmes have the potential to leapfrog to the most efficient technologies. In many countries, the falling costs of efficient lighting, such as LEDs, make them competitive with less efficient technologies (Figure 10). Likewise, more efficient inverter air conditioners are, in many cases, cheaper than less efficient units. EES&L programmes have the opportunity to encourage their uptake, driving down costs still further.

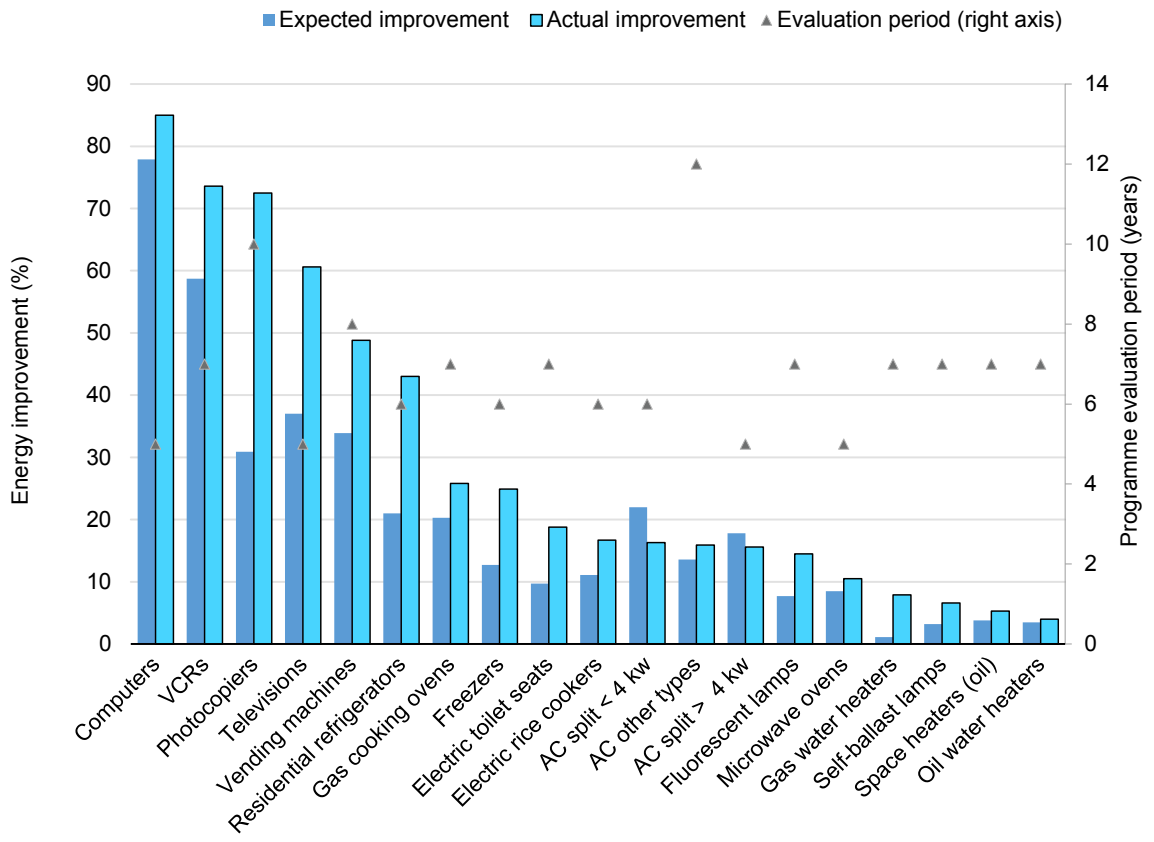
**Figure 10 Typical range of efficacy for different lighting technologies**




IEA and 4E TCP.

The Japanese Top Runner Programme is one good example of an EES&L programme. Figure 11 shows the estimated energy efficiency improvement before the implementation of the programme from ex ante studies versus the actual improvement observed from ex post studies. In almost all cases, the actual results of the EES&L exceeded original expectations, in many cases by a large margin.

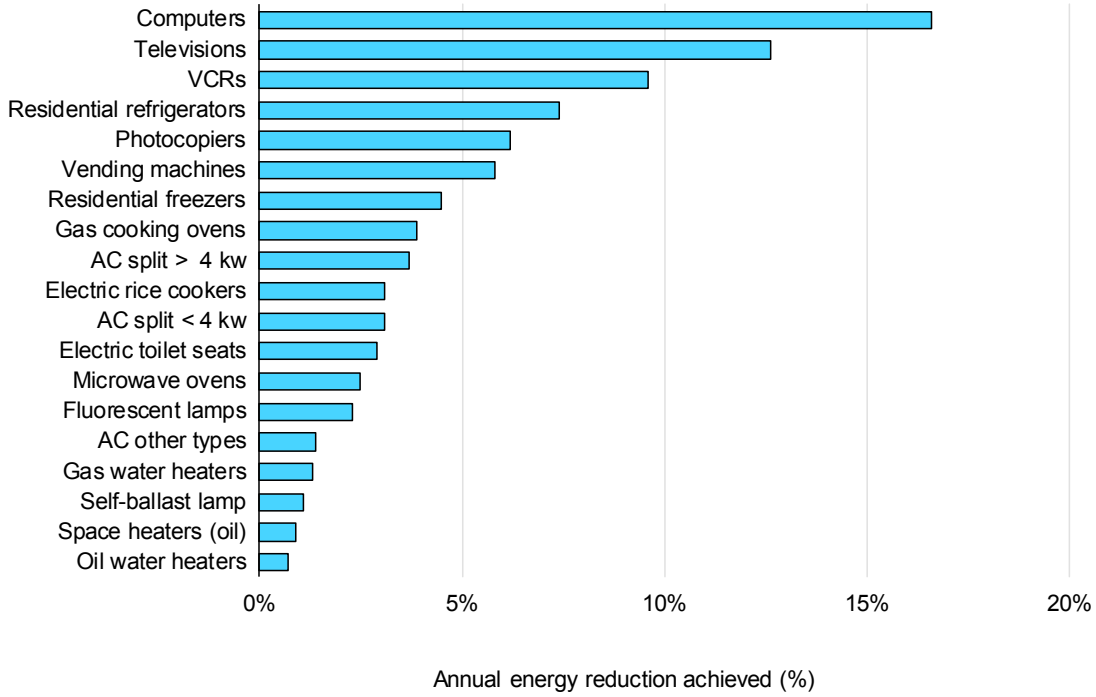
**Figure 11 Expected versus delivered improvements of the Japanese Top Runner Programme**




IEA and 4E TCP.

The average expected improvement rate across all products was 24%, while the average improvement rate actually achieved was 33% over moderate time frames of five to eight years. The annual actual improvement rates for selected individual products is shown in Figure 12.

**Figure 12 Annual energy improvement delivered by the Japanese Top Runner Programme**



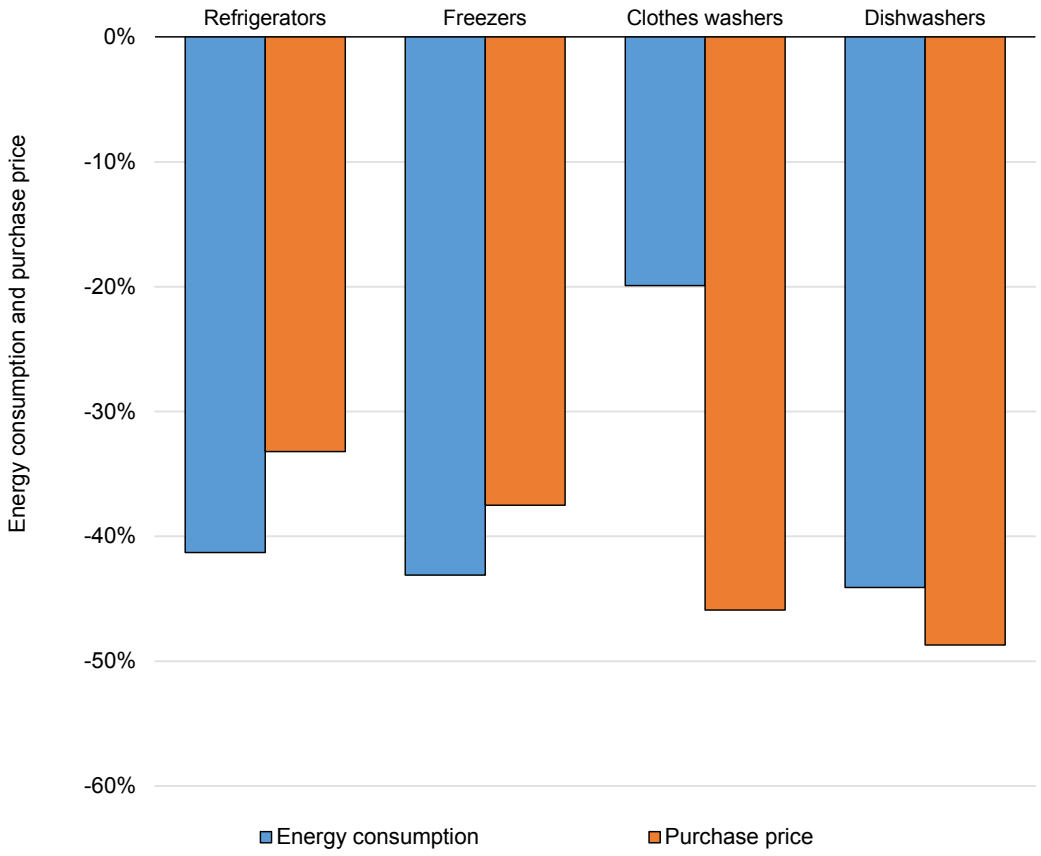

IEA and 4E TCP.

These results highlight not only the effectiveness of EES&L programmes in lowering the average energy consumption of appliances and equipment, but also the significant disparities between countries with advanced programmes, as opposed to countries with relatively new EES&L programmes where the impacts are still accruing.

# Impact of EES&Ls on innovation and appliance product prices

EES&L programmes have been an important driver of innovation in appliances and equipment since the 1970s. The need to meet performance requirements has demanded the invention of new technologies, manufacturing techniques and control systems that would not otherwise have been widely adopted. The fact that manufacturers have improved the efficiency of regulated products while reducing appliance purchase prices is clear evidence of their innovation (Figure 13).

**Figure 13 Changes in residential appliance prices and energy performance in Australia, 1993-2014**




IEA and 4E TCP.

These findings hold for a wide range of appliances across many countries. For example, air conditioning prices have fallen by approximately 2% per year, and

lamp ballast prices by 3% per year, while continuing to reduce energy consumption. In the case of residential refrigeration, washing machines and dishwasher products, average appliance prices have fallen around 2% per year, ranging from 1% to 5% for refrigerator/freezers and up to 4% for wet appliances.

Setting performance-based requirements across technologies is one specific way that EES&L programmes create space for innovation. This has enabled niche products and materials that offer very large efficiency improvements to gain sufficient market share and benefit from economies of scale. Notable examples include inverter-driven compressors, vacuum insulation for refrigeration systems and heat pump clothes dryers.

As an example, industry-led innovation offered dramatic efficiency increases in circulation pumps through the use of high-efficiency motors coupled with integrated variable speed drives. EU ecodesign regulations, supported by industry, have helped to underpin the transformation of the market, with recent rounds of ecodesign requiring all pumps sold to reach high-efficiency performance levels.

Some EES&L programmes also foster innovation through advanced signalling of future efficiency requirements. In Korea, this is achieved by adopting the previously highest energy label grade as the new minimum performance level approximately every five years. In Japan, the Top Runner Programme sets the efficiency target level some four to ten years in advance based on the best available technology. The sales-weighted average of all products shipped by each supplier is then required to meets this target.

EES&L programmes worldwide have also supported the wide-scale adoption of inverter technology in the air-conditioner industry, a significant change that provides a range of consumer benefits, especially lower energy bills. By developing new air-conditioner test methods and metrics that are more representative of consumer behaviour, EES&L programmes have helped demonstrate the real-life advantages of inverter technologies over conventional equipment to consumers.

Televisions and LED lighting have seen a technology revolution in recent years. The transformations that have occurred within these product categories have been rapid and profound and have been influenced by factors beyond energy efficiency. EES&Ls have played an important role in highlighting energy performance in consumer purchasing decisions and hence in the thinking of industrial product designers without any apparent detrimental effect on innovation.

These are just some of the many examples of how EES&L programmes have helped to stimulate innovation in appliance and equipment design globally through the creation of new markets for energy-efficient products.

# Other benefits from EES&L programmes

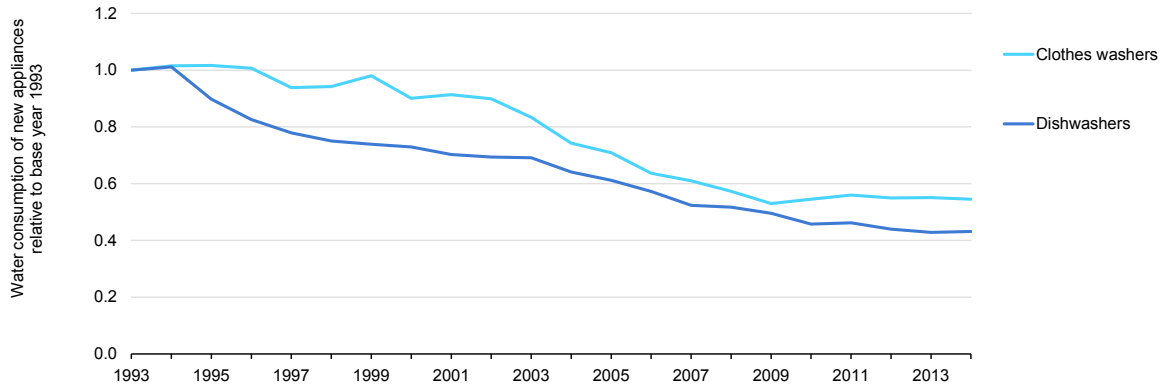
Other “co-benefits” from EES&L programmes include improvements to people’s comfort, health and finances, leading to stronger, more resilient regional economies. Accounting for these important benefits is often complex and has been less studied, but some countries are already factoring these into their cost/benefit analysis on EES&L programmes. Going forward, a stronger quantitative evidence set around these benefits will provide additional impetus for the development of EES&L programmes. In this chapter, we outline how EES&L programmes can create some of these co-benefits, including reduced water consumption and improved health outcomes.

## Reduced water consumption

Devices that are both energy- and water-efficient, such as low-flow showerheads, dishwashers and washing machines, can considerably reduce water consumption and sewage output. All economies that have regulated the energy performance of water-using products have reported reductions in both their energy use and their water consumption, as well as corresponding reductions in consumer energy and water bills. The most effective means of improving the energy efficiency of such products is to reduce the amount of water that must be heated required for them to fulfil their function.

For example, in the European Union, Australia and Canada, water consumption rates for regulated dishwashers and clothes washers have fallen by 3% to 4% annually over the last 20 years. By 2020, EES&L measures in the European Union reduced water consumption by over 1 800 billion litres, cutting water bills by more than EUR 8 billion. This is in addition to the EUR 5 billion consumers have saved on fuel costs. The longer-running US programme saved almost four times as much water in 2020.

**Figure 14 Changes in water consumption of new clothes washers and dishwashers in Australia, 1993-2014**




IEA and 4E TCP.

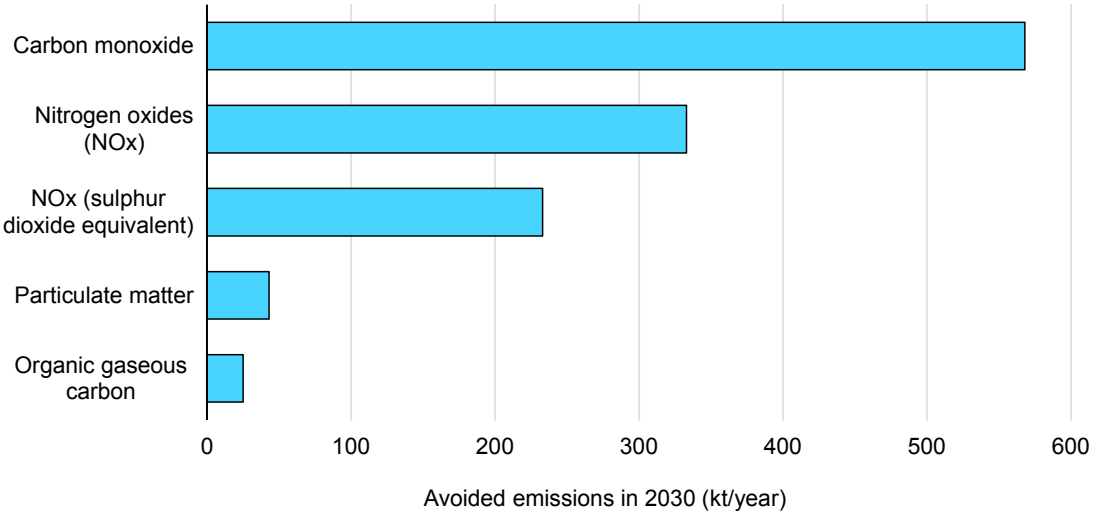
# Improved health outcomes

The health benefits of EES&L programmes are not often assessed, but there is emerging evidence that these benefits could be substantial and could become a key factor in the overall value proposition of these policy measures.

The main health benefit of energy-efficient equipment is reduced air pollution, thanks to reduced direct emissions from the combustion of gas, oil, coal and biomass for cooking and space and water heating as well as reduced indirect emissions from the burning of fossil fuels to produce electricity.

Figure 15 shows the projected avoided direct air emissions attributable to the EU EES&L programme for the year 2030. These results represent reductions of 22% in particulate matter, 20% in carbon monoxide and 11% in organic gaseous carbon compared with 2010 emissions levels.

**Figure 15 Projected reductions in direct airborne pollutants in the European Union due to EES&L programmes**




IEA and 4E TCP.

Health benefits are already a major part of the value proposition of EES&L programmes in some countries. In New Zealand, more energy-efficient space heating has created health cost savings around ten times the value of energy-related cost savings.

As new light is shed on the health impacts of fossil fuel pollutants, it seems likely that the role played by EES&L programmes will become increasingly valuable for policy makers.

# Conclusions

EES&L programmes are the “quiet achiever” among energy policies, as evidenced by this report, delivering large energy and cost savings and enabling the transition to a cleaner energy future. Evidence shows that EES&L programmes can deliver annual electricity demand savings on a par with the annual production of renewable energy. Reflecting the increasing recognition of such benefits, EES&L programmes have continued to grow in quantity to a greater number of countries and in scope to include a wider range of appliances and equipment.

As products currently covered by these programmes replace the existing stock, the size of EES&L savings will grow naturally. By this process, even a 2% annual improvement in stock energy efficiency will result in almost a 50% reduction in energy consumed over a 30-year period (Figure 19).

For this to occur, policy makers must regularly update EES&L policies to keep them in step with technological improvements. This demands adequate resources to ensure due diligence, including industry consultation. As indicated by the benefit/cost ratios, governments can expect multiplicative returns on their investments in programme planning and delivery.

There is substantial evidence that with sustained support from governments, EES&L programmes could deliver even more by expanding the scope of programmes to cover more products and by increasing the levels of ambition in policy settings.

Analysis of historic changes in product prices reviewed in this study indicates that products have continued to become more energy-efficient without becoming more expensive. In addition, most programmes have overestimated the costs of meeting product regulations. This suggests that more accurate, updated estimates of the impact on future product costs would make more stringent policy settings more cost-effective than previously considered.

To encourage greater coverage and ambition, this report has provided an important expansion of the evidence set on the real benefits of existing programmes so that they can be more accurately assessed and deployed. Given their importance to the global energy system and contribution to meeting net zero targets and UN Sustainable Development Goals, it is critical that governments and research bodies move to expand this evidence to fill in gaps, in terms of both new regions and the full range of benefits that EES&L programmes deliver.

# Annexes

## Methodology outline

The project methodology involved an extensive international review of the published reports and conference papers, including nearly 400 reports and papers covering more than 100 product types, which deal with the impact evaluation of energy efficiency programmes. Of these, 81 were found to contain substantive quantitative data relevant to this study. The distribution of these reports by region is shown in Table A1.

**Table A.1 Summary of reports reviewed in 2021 by region**

| Region | Total sources reviewed | Total sources used in this report |
|---|---|---|
| International | 50 | 3 |
| Africa | 22 | 2 |
| Asia | 81 | 24 |
| Central/South America | 22 | 10 |
| Europe | 92 | 9 |
| Middle East | 0 | 0 |
| North America | 86 | 20 |
| Oceania | 42 | 13 |
| **Total** | **395** | **81** |

Many leading energy efficiency experts from around the world were consulted on suitable studies that could be utilised as part of the evidence base for this study. The majority of the reports and studies examined were either produced by governments, commissioned by governments or prepared with the co-operation of governments. Wherever possible, multiple sources were identified to corroborate the findings.

In selecting which published data to include, comprehensive ex post studies were given the highest weighting, as these tend to provide the most reliable evidence base of savings achieved in practice. This is particularly true where these address key attributes such as capacity changes, ownership trends, sales and actual efficiency using a decomposition approach in the analysis. However, formal ex post evaluation studies, where energy savings are estimated from a review of

historical data after programme implementation, are not common in the published literature.

MEPS impacts are generally easier to estimate, and many ex ante estimates of energy savings have been validated through ex post evaluation studies. This is because MEPS define an efficiency benchmark for all products and therefore provide some certainty regarding the future programme impacts. In contrast, it can be more challenging to estimate the future impact of labelling programmes before they are introduced, particularly voluntary labelling programmes, as the savings achieved rely on consumer and manufacturer market responses. For this reason, ex post studies were generally considered more robust and accurate in terms of estimating energy savings achieved by labelling programmes.

Few reports examined document in any detail the issue of attribution of claimed energy savings. Attribution can be quite important where there are several programmes that overlap and/or where there is rapid technology change driven by factors unrelated to energy efficiency.

Although considerable credible evidence has been collated during the course of this study, for the further development of EES&L programmes it is important that more countries undertake ex post assessments of their programmes impacts. This is a highly specialised field, but one well-suited to the sharing of expertise among countries and the allocation of more resources by policy makers.

# Abbreviations and acronyms

| | |
|---|---|
| 4E | Energy Efficient End-use Equipment Technology Collaboration Programme |
| AC | air conditioning |
| COP | Conference of the Parties |
| EES&L | energy efficiency standards and labelling programmes |
| EU | European Union |
| Ex ante | Before an event; term used in policy appraisals to indicate that savings estimates are undertaken before the measure has been implemented |
| Ex post | After an event; term used in retrospective policy evaluation to indicate that savings estimates were done after the measure has been implemented |
| IEA | International Energy Agency |
| MEPS | minimum energy performance standards |
| SEAD | Super-efficient Equipment and Appliances Deployment (Initiative) |
| TCP | Technology Collaboration Programme |
| US | United States |
| Wet appliances | Category including washing machines, dryers and dishwashers |

# Units of measurement

| | |
|---|---|
| Kt | kilotonnes |
| kw | kilowatt |
| Mt | million tonnes |
| TWh | Terawatt hour |

## IEA and 4E TCP (2021)

This publication is the result of a collaborative effort among the International Energy Agency (IEA) and the Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E TCP).

This publication reflects the views of the IEA Secretariat and the 4E TCP but does not necessarily reflect those of their respective individual member countries or members. The IEA and the 4E TCP make no representation or warranty, express or implied, in respect of the publication's contents (including its completeness or accuracy) and shall not be responsible for any use of, or reliance on, the publication/work.



International Energy Agency
Website: www.iea.org
Contact information: www.iea.org/about/contact
Typeset in France by IEA – September 2021
Cover design: IEA
Photo credits: © Shutterstock


12:34
COOKER
WASHING
MACHINE
6kg
Water Action