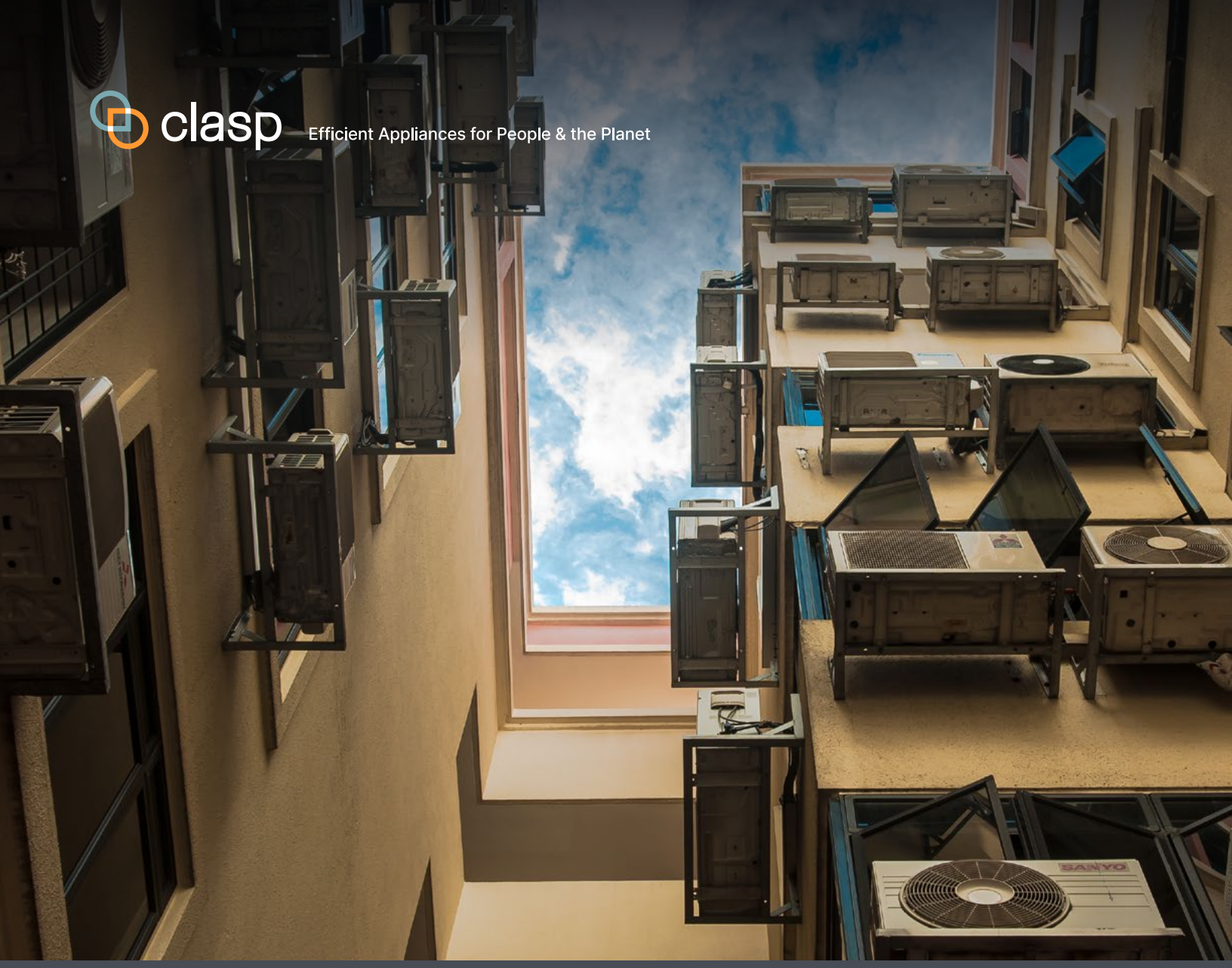
clasp Efficient Appliances for People & the Planet



Getting Appliances Back on Track:

Assessing Progress Towards Global Energy Efficiency Commitments

5 OCTOBER 2023

Acknowledgements and Citation

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DISCLAIMER

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Executive Summary

In the lead-up to COP26, governments around the world came together in a historic agreement to double the average energy efficiency of key appliances by 2030. But in the two years since, they have not kept pace with their commitments. To meet critical climate targets, all nations – and, in particular, the top emitters – must act quickly.

As energy demand grows around the world, national governments face the pressing challenge of meeting people's needs while reducing emissions in keeping with the Paris Climate Agreement. Improving the energy efficiency of vital appliances like air conditioners, lighting, refrigerator-freezers, and electric motors is key to achieving both goals.

In 2021, 15 nations (Figure 1) came together ahead of COP26 to create the largest-ever global commitment to reducing appliances' energy use.[1a] However, CLASP analysis shows that two years later, the signatories of the Super-efficient Appliance & Equipment Deployment (SEAD) Initiative Appliance Efficiency Call to Action[b] are not on track to hit their targets.

As the international community takes stock of climate mitigation progress in advance of COP28, it's clear that now is the time for all governments to take urgent action on appliance efficiency.

KEY FINDINGS

Our analysis reveals that among the 15 signatories, the current pace of progress is too slow to achieve a doubling of the average efficiency of priority appliances and equipment by 2030. As of mid-2023, only two appliance/signatory combinations were on track to meet this goal.[c]

CLASP gathered publicly available market data from the 15 signatory nations, where available, and compared the energy consumption of new appliance models to corresponding data from 2021. (In cases where 2021 data was not available, we used information from the most recent year prior to 2021.) To highlight additional global opportunities for government intervention, we extended the analysis to four top-emitting nations that did not sign the agreement: Canada, China, South Africa, and the United States. Table 1 summarizes the analysis scope.

[a] Signatories include Australia, Brazil, Chile, Colombia, Denmark, Germany, Ghana, India, Indonesia, Japan, Nigeria, Panama, South Korea, Sweden, and the United Kingdom.

[b] To be referred to as "Call to Action." https://www.cleanenergyministerial.org/initiatives-campaigns/super-efficient-equipment-and-deployment-sead-initiative/?_years=2021

[c] Though reports such as this are vital in understanding the status of progress, the necessary data was often inaccessible or did not exist. CLASP's analysis therefore presents only a partial view of the state of the commitments, as the pace of progress is unknown for most signatories and products. Nonetheless, what we can quantify indicates that we are far off track to achieve the Call to Action goals.

FIGURE 1: CALL TO ACTION SIGNATORIES: AUSTRALIA, BRAZIL, CHILE, COLOMBIA, DENMARK, GERMANY, GHANA, INDIA, INDONESIA, JAPAN, NIGERIA, PANAMA, SOUTH KOREA, SWEDEN, UNITED KINGDOM

TABLE 1: CATEGORIES OF APPLIANCES ANALYZED IN THE REPORT ACROSS 15 SIGNATORIES AND FOUR TOP EMITTERS

ENERGY-INTENSIVE APPLIANCE CATEGORIES ANALYZED	CALL TO ACTION SIGNATORIES (15)	OTHER TOP EMITTERS (4)
General Service Lamps (incandescent, compact, fluorescent [CFL], and light-emitting diode [LED] bulbs) Electric Motors Split Air Conditioners Refrigerator-freezers (residential refrigerators with a frozen-food compartment)	Australia Brazil Chile Colombia Denmark Germany Ghana India Indonesia Japan Nigeria Panama South Korea Sweden United Kingdom	Canda China South Africa United States

TABLE 2: AVERAGE EFFICIENCY OF KEY APPLIANCES ON THE MARKET ACROSS THE SIGNATORIES WHERE DATA WERE AVAILABLE COMPARED TO LINEAR PROGRESS TOWARD THE CALL TO ACTION EFFICIENCY-DOUBLING GOAL. "ON TRACK" MEANS THAT IF A SIMILAR PACE OF EFFICIENCY IMPROVEMENT WERE TO CONTINUE, EFFICIENCY WOULD DOUBLE BY 2030. WE DID NOT FIND SUFFICIENT DATA TO MAKE AN ASSESSMENT FOR THE REMAINING SIGNATORIES.

	PROGRESS OF SIGNATORIES ON EFFICIENCY IMPROVEMENT OF AVERAGE NEW MODELS ON THE MARKET
General Service Lamps	Unknown
Electric Motors	0 on track 3 not on track
Split Air Conditioners	1 on track 7 not on track
Refrigerator-freezers	1 on track 5 not on track

The primary policy governments use to increase efficiency or reduce energy consumption of new appliances and equipment entering the market is minimum energy performance standards (MEPS). Several signatories have developed new or revised MEPS since 2021, and many of these support the Call to Action goal by either doubling the efficiency of the least-efficient products on the market or taking an incremental step toward doing so by 2030.

However, most signatories have not adopted new or revised MEPS since 2021. Furthermore, doubling the stringency of MEPS will likely be insufficient to achieve a doubling of average efficiency, as their role is to eliminate the least efficient products from the market. Many governments also devote relatively few resources to compliance efforts for these policies, potentially reducing MEPS' effectiveness.

RECOMMENDATIONS

- All nations should align their MEPS for lighting, electric motors, air conditioners, and refrigerators with United for Efficiency (U4E) Model Regulation Guidelines.[2] To achieve doubling by the end of the decade, further updates to MEPS will likely be necessary. Policymakers should find it easier and faster to update MEPS once they are established, and once data on product efficiency is routinely collected and can be used for analysis.
- Nations that already meet the standards described in CLASP's companion publication, World's Best MEPS,[3] should target the U4E advanced tier or other advanced levels in IEA's policy ladders.[4]
- Policymakers can also leverage labeling to accelerate the efficiency of products in the market. This path can be fruitful in nations where governments are constrained[d] from doubling the ambition of MEPS by 2030.
    - In some nations (e.g., Brazil), labeling programs already function as de facto MEPS, with most consumers choosing the highest-labeled product.

[d] Constraints are often economic. Higher-efficiency products may not always be as cost effective, particularly in terms of first cost. Furthermore, it may be impractical for policymakers to revise a policy multiple times before 2030.

- Nations should take the following appliance-specific actions (based on the analysis in World's Best MEPS):
    - **Lighting:** Policymakers should set technology-neutral MEPS at a luminous efficacy of 90 lumens per watt (lm/W) to enable a full transition to LED lighting. LED lighting is 50% more efficient than fluorescent lighting and does not contain mercury, a harmful neurotoxin.[5] Nations with stringent lighting MEPS should strive for even better policies, setting new standards at 120 lm/W.
        - While not in the scope of this report, we also recommend that for linear/tubular lighting, policymakers adopt ambitious, technology-neutral MEPS aligned with the U4E model regulations. Linear fluorescent lighting is responsible for a large share of commercial buildings' electricity consumption; higher efficacy can both reduce energy consumption and eliminate mercury-containing fluorescent technology.
        - At the 2022 UN Minamata Convention on Mercury 4th Conference of the Parties (COP4), 137 nations agreed to ban compact fluorescent lamps (CFLs).[6] Implementing technology-neutral MEPS at 90 lm/W would achieve this goal.
        - In addition, there is a proposal to ban linear fluorescent lamps at the upcoming COP5. Policymakers should support this ban, as it would reduce energy consumption and mercury pollution, as well as support Call to Action pledges.
    - **Refrigerators:** At a minimum, all governments should set MEPS harmonized to the U4E model regulations (279 kWh/year for a 400 L refrigerator-freezer evaluated at an average of 16 and 32 °C, scaled appropriately to local capacities and test conditions). Nations that have already achieved this target should increase their stringency to match U4E's next target (223 kWh/year or less, again for 400 L and average of 16 and 32 °C).
    - **Air Conditioners (ACs):** Governments should take advantage of the fact that the technology and supply chain needed to enforce stricter MEPS in alignment with U4E AC model (cooling seasonal performance factor [CSPF] 6.1 Wh/Wh for 3.5 kW cooling-only units, as tested regulations per the International Organization for Standardization [ISO] standard 16358:2013) are already in place.
        - The main global exporter of ACs is using the U4E regulation for its domestic market, providing importing nations with a potential opportunity to enforce the same requirements.
        - ASEAN nations have already agreed to harmonize their MEPS at the U4E level by 2025, while China is considering a higher efficiency at ISO CSPF 8 Wh/Wh by 2027.
        - Meanwhile, the Global Cooling Prize competition demonstrated technology that reduced AC energy consumption by a factor of five.
    - **Electric Motors:** Beyond setting motor MEPS at international efficiency levels 3 or 4 (IE3 or IE4), as defined in International Electrotechnical Commission (IEC) standards 60034-30-1 and 60034-30-2, policymakers can further reduce the energy consumption of motor systems through requirements for variable speed drives and MEPS for motor applications, such as pumps, air compressors, and industrial fans and blowers.

Background & Purpose

Energy efficiency is a proven, scalable, and accessible tool for policymakers aiming to cut energy use and mitigate the effects of our technology on the planet. Governments from across the globe are signaling their willingness to leverage energy efficiency policy to combat the climate crisis, offering their commitments to action on the world stage.[7]

Electric motors, air conditioners (ACs), refrigerators, and lighting account for more than 40% of global electricity consumption.[8] Doubling the aggregate efficiency of these appliances would avoid over 2 gigatons (Gt) of carbon dioxide (CO_2) emissions in 2030.[9] To this end, and motivated by the United Nations Framework Convention on Climate Change (UNFCCC) 26th Conference of the Parties (COP26) in 2021, 15 countries signed the Super-efficient Appliance & Equipment Deployment (SEAD) Initiative Appliance Efficiency Call to Action. This was estimated to be the largest energy efficiency commitment ever.[10]

The 15 signatories agreed to "help Governments raise the efficiency of high energy-consuming products" through one or more of the following actions:

- "To work towards aligning our product standards with the goal of doubling the energy efficiency of products sold globally by 2030 in order to meet our Paris goals, and to advocate for this internationally;
- To commit to leading or co-leading a programme of action on one of the four high energy-consuming products associated with the COP26 Call to Action, or another globally relevant high energy-consuming product, and identifying opportunities in pursuit of the 2030 goal;
- To actively engage in efforts to promote ambitious products policy nationally, regionally, and globally to create stronger incentives, larger markets, and lower costs for more efficient products."[11]

By reviewing publicly available data on product efficiency in the market and Minimum Energy Efficiency Performance Standards (MEPS) in the signatory countries, we attempt to evaluate progress toward the first Call to Action goal: "doubling the energy efficiency of products" and "aligning our product standards." We focus on several major categories of the four appliances within the scope of the Call to Action (general service lamps, electric motors, split ACs, and residential refrigerator-freezers). Finally, in addition to the signatories, we analyze four other top emitters.

This report is a continuation of a previous report on World's Best MEPS, which provided a snapshot of the stringency of MEPS for six key products (the four Call to Action products, plus space and water heating) across 10 top-emitting nations (including the European Union).[e] Here, we delve deeper by evaluating the efficiency of products in the market, which may exceed the local MEPS levels.

It is notable that there is often a lag between the adoption of policies and changes in the market due to a transition period. While some markets begin changing in anticipation of a regulation's adoption, this is not always the case, and nations' markets may reflect lower efficiency products despite having recently adopted ambitious MEPS.

This report will help those governments already committed to improving the energy efficiency of appliances to meet climate goals. Through our analysis and recommendations, we seek to achieve the following two goals:

1. Evaluate signatory commitments under the Product Efficiency Call to Action[12] to encourage further action to get back on track toward the doubling goal; and

2. Encourage other nations to join the Call to Action, or otherwise work to double the average efficiency of products sold on their markets.

[e] World's Best MEPs is an ongoing project at CLASP and will be periodically updated in the coming years.

Methodology

Rather than commit to a specific efficiency level for each product, the Call to Action signatories committed to "doubling the energy efficiency" of motors, refrigerators, lighting, and air conditioners by 2030. While some countries signed the Call to Action pledge in 2020, the majority signed around COP26 in 2021. Therefore, this report reviews progress since 2021, using data from earlier years if no 2021 data were available.[f]

Our analysis compares the average efficiency and MEPS within each economy over time. The average efficiency is typically calculated by averaging the efficiency of all the models available on the market or, if sales data is available, by averaging the sales-weighted efficiency. Meanwhile, MEPS is defined as the minimum efficiency or maximum energy allowed for a representative product type and capacity (e.g., 7 kW split AC). All products of that type and capacity must have efficiency higher than this minimum.

AVERAGE EFFICIENCY ON THE MARKET

For the average efficiency of products on the market, we reviewed historical reports and analyses from 2021 and prior for each of the product categories. We then consulted present-day product databases and applied the same methodology to calculate the average efficiency for each representative unit. For example, if a historical analysis presented only the efficiency of 3.5 kW ACs, we would filter for 3.5 kW units in the product database and average their performance. This should isolate efficiency progress, while ignoring any changes in consumer preferences related to capacity or other features.[g]

Finally, in addition to filtering products to select the same capacity, we filtered products by availability and date of listing in the database. Many databases keep products listed over many years, past the point when these products are likely to still be on the market. On the other hand, only analyzing products available in one year might leave out models that had not been refreshed. To that end, in cases where databases provided the date of first listing, we chose the following number of years of models to include in the analysis. For example, to evaluate the average performance of refrigerators in the market in 2021, we analyzed the performance of models listed in 2021, 2020, and 2019 (3 years). The maximum age of the models included in the analysis is listed in Table 3.

TABLE 3: MAXIMUM AGE OF MODELS USED IN ANALYSIS IF THE DATE OF LISTING WAS INCLUDED IN THE DATABASE

APPLIANCE & EQUIPMENT CATEGORY	MAXIMUM AGE OF MODELS INCLUDED IN ANALYSIS (YEARS)
Lighting	2
Air Conditioners	3
Refrigerators	3
Motors	5

MEPS

For each nation's MEPS, we reviewed policy documents and identified the requirements for a representative product in cases where there were multiple requirements that varied with size (for example, in China the MEPS requirement for cooling-only ACs is 6.1 Wh/Wh ISO CSPF for 3.5 kW units and 5.1 Wh/Wh ISO CSPF for 7 kW units). The representative unit capacity will vary among nations, but is consistent for a given nation throughout the analysis period.

We used the same representative units as in World's Best MEPS. These may be found in most nations but may not be the most common within a particular nation, such as a 800 lumen non-directional lamp, 7 kW/2 ton split air conditioner,

[f] We reviewed the effects of tracking progress since 2020 for ACs, and the change was small. As historical data were sparse, we often used 2020, 2019, or even 2018 data regardless of whether 2020 or 2021 was used as the baseline. Additionally, while the needed pace of efficiency improvement would be slower with a 2020 baseline (11 years from 2020 to 2030, inclusive, versus 10 years from 2021 to 2030), signatories would need to achieve more by 2023 (85% energy consumption relative to 2020, versus 88.9% energy consumption relative to 2021). The net result was that the one signatory who is currently listed as on track would not be on track with a 2020 baseline.

[g] Reducing capacity of the typical product is another path to the energy reductions required by the Call to Action. For example, insulating a home can reduce the capacity of the air conditioner needed to cool the home. Our analysis would miss such effects when filtering for a particular product class.

or 400 L refrigerator-freezer. While it is possible that choosing a different representative unit could result in a different rate of MEPS improvement, by choosing a typical type or capacity, we hope that we will be reflecting the increased ambition for a sizable share of products.

It should be noted that the requirements we examined for Japan are not MEPS. In contrast with other nations, Japan sets targets for the shipment-weighted average performance of products, rather than setting a minimum energy efficiency level. This means that some models sold in the Japanese market can fall below the indicated target. For these reasons, Japan is excluded from the MEPS evaluation and graphs; however, details on their Top Runner requirements are included in Appendix A.

Comparing appliance MEPS, while challenging, is a worthwhile endeavor. Nations are falling short in their commitments to the Paris Climate Agreement. As a result, the global community is not on track to limit warming to well below 1.5° C, placing countries at greater risk of the worst impacts of climate change.[13] MEPS are a widely used and cost-effective tool available to governments that want to minimize the negative climate impacts of appliance use.

A 2021 analysis of 12 standards and labeling programs found that the administrative costs required to achieve a one-ton reduction of carbon dioxide equivalent (CO_2e) ranged from $0.01 per ton to $1.00 per ton.[14] Meanwhile, society as a whole experiences a net benefit from standards and labeling, with energy cost savings exceeding any expected increase in the up-front cost of products. For example, standards adopted in the United States have been saving each household USD $340/year,[15] with forthcoming revised standards adding another USD $100/year once finalized.[16]

All data sources and analytical steps are summarized by country and product in Appendix A.

Results & Recommendations

Based on our aforementioned analyses, we outline our findings per priority appliance category and offer recommendations for how to improve the pace of efficiency efforts to align with the Call to Action goal.

A NOTE ON THE GRAPHS

In the first graph of each section, we show average appliance performance before and after the Call to Action was announced in 2021, using the local efficiency or energy metric and test method. Then, in the second graph, we turn any efficiency metrics into an equivalent energy use. For example, we invert the efficiency of split ACs such that an efficiency of 4 Wh/Wh ISO CSPF becomes ¼, which is proportional to the ACs' energy use. Next, we normalize this energy use to the value in 2021, dividing by the value in 2021 and multiplying by 100.

The Call to Action requires a doubling of efficiency, but the goal is to be evaluated as a "50% reduction in the average energy consumption."[17] The procedure above makes it easy to see progress against the doubling goal. Instead of trying to spot a doubling in a variety of efficiency metrics, which can vary by appliance and by country, we instead present the normalized energy use and evaluate whether it is decreasing from 100 to 50.

Furthermore, the normalized energy use allows for a consistent presentation with refrigerator-freezers, which are usually evaluated in terms of annual energy consumption instead of efficiency. The conversion also avoids confusion in the case of motors, where the full load efficiency cannot double. (In some cases, they are already at 90% and cannot exceed 100%).[h]

In the third graph, we show any changes in MEPS since 2021 using the local efficiency or energy metric and test method. These changes help visualize recent policymaker actions and point out where average efficiency may change in the coming years as the MEPS take effect. However, as the Call to Action doubling goal applies to the average unit and not the MEPS, we did not normalize the MEPS as we did the average efficiency.

Finally, for clarity, we are only including countries for which we have been able to collect average efficiency data or that have implemented MEPS changes since 2021.

[h] For lighting and air conditioners, we took the multiplicative inverse of efficacy or efficiency to develop a metric proportional to energy. For motors, we calculated the losses through the motor at full load (1/eff – 1). Refrigerators are typically rated in terms of their energy consumption or an index proportional to energy consumption, so in most cases no transformation was necessary.

General Service

The Call to Action applies to all "residential and professional general-services lighting".[18] Our analysis assessed non-directional general service lamps (GSL), usually used in residential settings. If a policy or data source did not explicitly state that they were for GSL, we looked for key terms such as "screw-based bulbs," that would classify a lighting product as a GSL.

GENERAL SERVICE LAMP AVERAGE EFFICIENCY ON THE MARKET

Due to a lack of technology-neutral MEPS, there is an incomplete view of the market. Most countries only regulate and collect data for some types of GSL, for example, light-emitting diodes (LEDs). Meanwhile, there is no data on the unregulated lamps (typically incandescent), which because of their extremely low efficacy, can greatly affect the average efficiency. As a result, we were unable to find efficiency data since 2021 to evaluate progress against the doubling goal.

FIGURE 2: AVERAGE EFFICIENCY ON THE MARKET FOR GENERAL SERVICE LAMPS USING THE LOCAL EFFICIENCY METRIC. ONLY COUNTRIES WITH DATA ARE SHOWN.

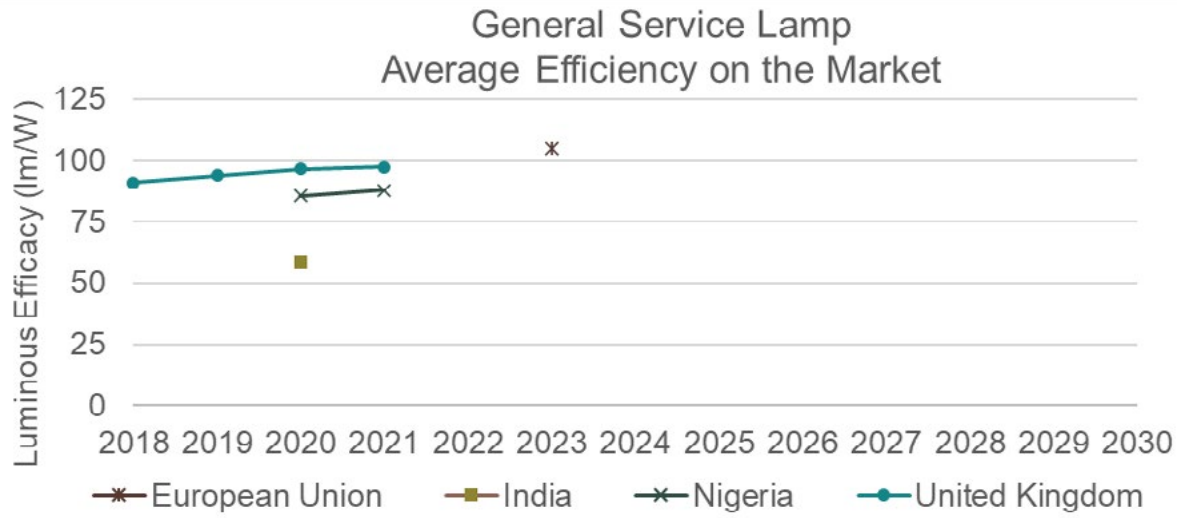
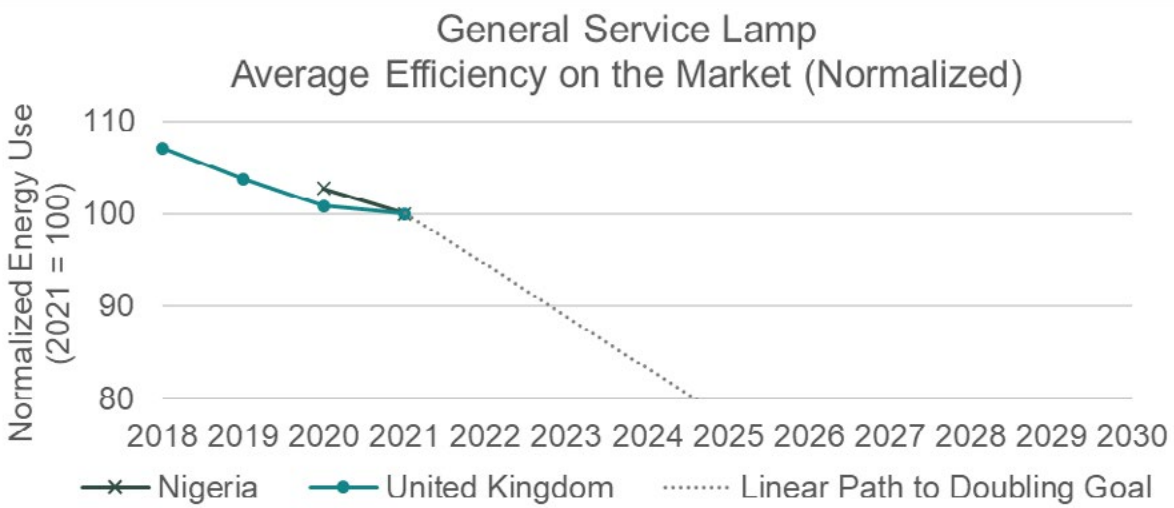


FIGURE 3: AVERAGE EFFICIENCY ON THE MARKET FOR GENERAL SERVICE LAMPS EXPRESSED IN TERMS OF NORMALIZED ENERGY USE, TO EASILY SEE THE LINEAR PATH TO 50% REDUCTION/DOUBLING GOAL. WE CALCULATED THE NORMALIZED ENERGY USE FOR LAMPS BY TAKING THE INVERSE OF THE EFFICACY AND THEN DIVIDING BY THE VALUE IN 2021 OR EARLIER. ONLY COUNTRIES WITH DATA ARE SHOWN.



GENERAL SERVICE LAMP MEPS

We analyzed MEPS across all lighting technologies (LEDs, incandescent, CFLs). If a country did not have a technology-neutral MEPS and still had MEPS that allow incandescents or CFLs, we used those as the MEPS level. Even if the country has separate ambitious MEPS in place for LEDs, inefficient CFL and incandescent lamps can continue to be imported and reduce the average efficiency on the market.[i] For our representative unit, we followed World's Best MEPS and used an 800 lm lamp.

Most nations analyzed do not show any clear MEPS progress since 2021, as most still have technology-specific regulations that permit the legacy inefficient lamps. (See Table 4).

TABLE 4: STATUS OF GENERAL SERVICE LAMP MEPS

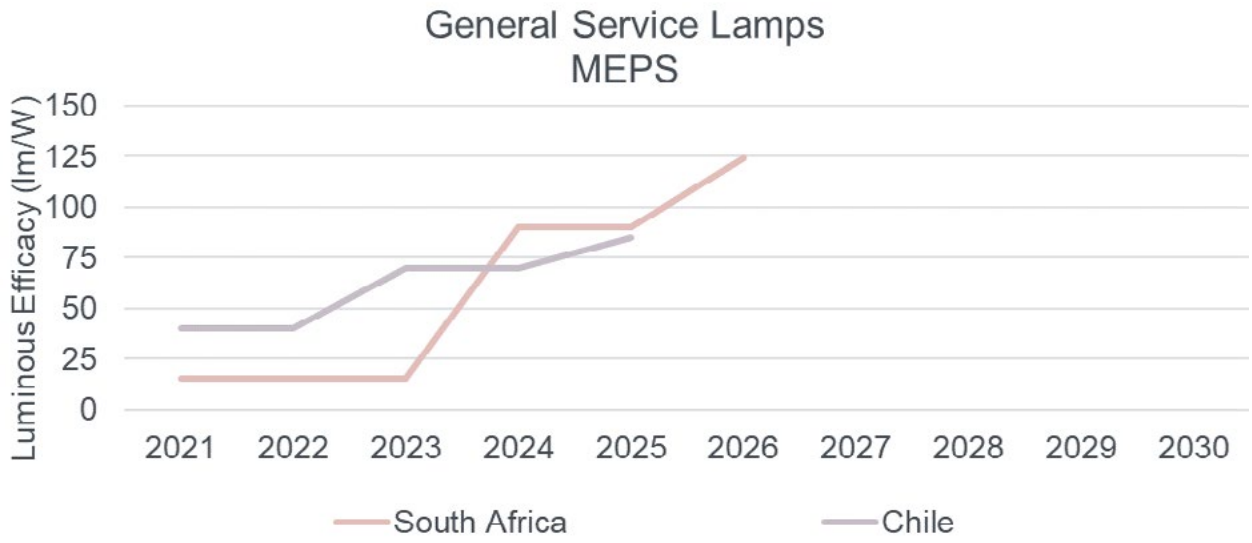
		CALL TO ACTION SIGNATORIES (15)	OTHER TOP EMITTERS (4)
MEPS Updates Support Doubling Efficiency by 2030		Chile	South Africa
MEPS Not on Track	MEPS Revisions Proposed	Australia, Nigeria, United Kingdom	United States
	MEPS Recently Updated to World's Best MEPS (Future Revision Opportunity)	Denmark, Germany, Sweden	
	Weak or Technology-Specific MEPS Keeping Inefficient Products on the Market	All others	Canada, China
	Unknown or No MEPS	Japan (Top Runner only), Colombia	

Despite most nations falling under the "weak or technology specific MEPS" category, there are signs of progress. A prime example of an economy that has adopted more stringent requirements that support doubling efficiency is Chile. Despite having a relatively low MEPS of 40 lm/W in 2021 (an efficacy level that excludes incandescents, but not CFLs), Chile has adopted more stringent requirements at 70 lm/W in 2023 and 85 lm/W in 2025 (this will exclude CFLs and low-quality LEDs).[19]

Among other top emitters, South Africa has recently adopted MEPS at 90 lm/W, which will take effect in May 2024. After two years, the second tier will be enforced at 105 lm/W.[20] The US technically made progress from 18.6 to 45 lm/W in 2022; however, the higher standard was originally scheduled for 1 January 2020, but was delayed to 2022, therefore it is not a new commitment. This progress is illustrated in Figure 4.

[i] Market studies could indicate whether legacy lamps continue to be used and whether it is necessary to close these loopholes.

FIGURE 4: NEW OR REVISED GENERAL SERVICE LAMPS MEPS REQUIREMENTS FOR 800 LUMEN LAMPS, USING THE LOCAL EFFICIENCY METRIC. ONLY COUNTRIES THAT HAVE MEPS TAKING EFFECT SINCE 2021 ARE SHOWN.



Governments that are signatories to the Minamata Convention on Mercury are required to ban CFLs from their markets by 2025. This provides an opportunity to enforce ambitious technology neutral MEPS that will also get rid of incandescents and inefficient LEDs. Enforcing technology neutral MEPS at 90lm/W is the easiest way for nations to simultaneously comply with Minamata and ensure that there is no backsliding to incandescent or inefficient, low-quality LEDs in their market. At Minamata COP5 in 2023, there will also be a new proposal on banning linear fluorescents, which provides a larger energy reduction opportunity for nations to transition to LEDs.

Adopting a 90 lm/W regulation across all luminance levels would ensure inefficient CFLs and incandescent bulbs are phased out in line with U4E's model regulation guidelines.[21] With the rapid improvement in LED technology, there is an opportunity for further revision in the near future. There are already lamps at 210 lm/W in the EU market,[22] and the US and UK recently proposed MEPS at 124 lm/W[23] and 140 lm/W,[24] respectively.

There are four signatories (Sweden, Germany, Denmark, and the UK) that have not made further progress since adopting world leading MEPS in 2021, along with the rest of the European Union (90 lm/W for 800 lm lamps). Article 9 of the EU regulation states that an evaluation and potential revision is required by 25 December 2024.[25]

LOOKING AHEAD

As we recommended in World's Best MEPS[26]:

- To drive a shift to more efficient LED lighting, all nations should adopt a common minimum efficacy target for all light source technologies (preferably by use of a single technology neutral standard for lamps) via a MEPS with a minimum luminous efficacy of 90 lm/W, which is aligned with 22 African nations, the EU, and the UK, and is consistent with the guidance of U4E's model regulations. Doing this before 2025 will reduce mercury pollution[i] from CFLs beyond the agreed commitments and will help achieve the goals of the Minamata Convention.
- Nations that already meet the 90 lm/W target could push ambition to 120 lm/W. Nations adopting 90 lm/W could also set 120 lm/W as a second tier in their MEPS, with a compliance date further in the future to help the regulation keep up with ongoing technological improvements of LED lighting, including the existing availability of 210 lm/W lamps in the EU and other markets.

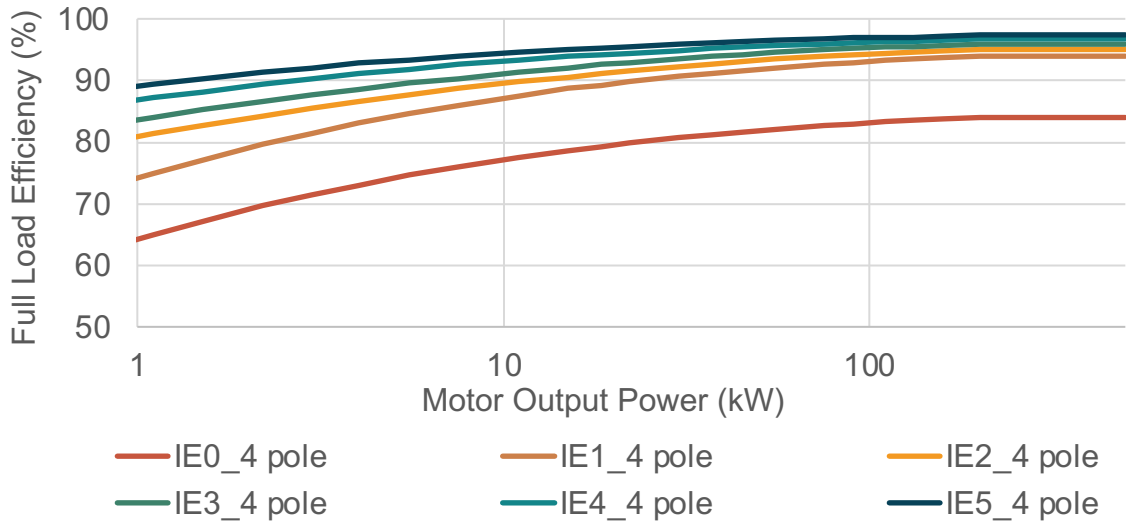
[i] Mercury is highly toxic to humans, which is why the World Health Organization lists it among the top 10 chemicals or groups of chemicals of major public health concern.

Electric Motors

Electric motors with an output power of 0.75-375 kW (1-500 horse power) are included in the Call to Action. The Call to Action also references the "motor system", which would include the additional components that control the motor, as well as turn its rotating output into useful work (e.g., fans, pumps, or compressors).[27] However, due to the complexity of targeting these components or both the components and the motor, we narrowed our analysis to only encompass 3-phase motors.

International MEPS typically reference IEC standards 60034-30-1 and 60034-30-2, which set "international efficiency" (IE) standards at five levels, IE1 through IE5. Most of the nations analyzed fall within the IE3 efficiency category, and some are transitioning to IE4.

FIGURE 5: FULL LOAD EFFICIENCY VS. MOTOR OUTPUT POWER



As can be seen in Figure 5, for an 11 kW motor, a transition from IE3 to IE5 would increase the required full-load efficiency from 91.4% to 94.6%. Put another way, it would reduce losses from 8.6% to 5.4%, a percentage difference of 37%, thereby approaching the doubling goal of the Call to Action. However, that loss reduction is a decrease of only 330 W and ignores up to 11 kW that pass through the motor and are potentially wasted in the downstream components (motor loads such as fans, pumps, and compressors; valves and dampers; piping and other industrial components).

Halving the energy consumption of the entire motor system is a much bigger prize and is necessary to achieve Net Zero and Paris Agreement goals. To do this, governments will need additional reductions from downstream system efficiency improvements, which require components such as variable-speed drive, pumps, fans, and compressors to be regulated alongside motor MEPS. Tracking progress on overall system efficiency could be a focus for future work.

ELECTRIC MOTOR AVERAGE EFFICIENCY ON THE MARKET

The full load efficiency of new motors across the nations analyzed revealed little progress, with increases in only one.

FIGURE 6: AVERAGE EFFICIENCY ON THE MARKET FOR ELECTRIC MOTORS USING THE LOCAL EFFICIENCY METRIC. ONLY NATIONS WITH DATA ARE SHOWN.

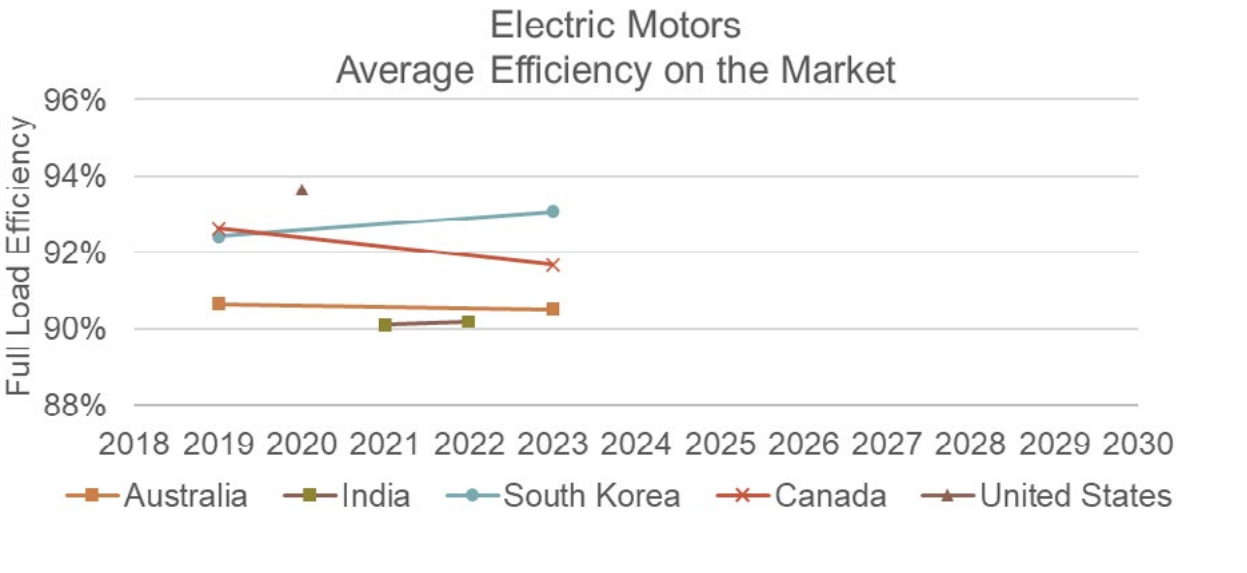
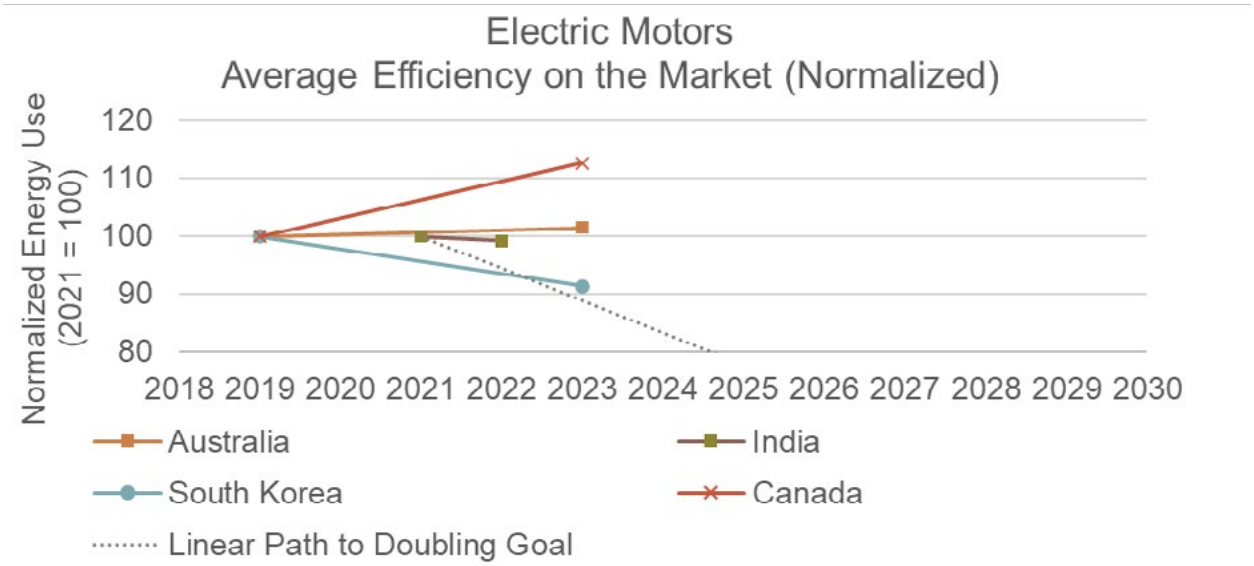


FIGURE 7: AVERAGE EFFICIENCY ON THE MARKET FOR ELECTRIC MOTORS EXPRESSED IN TERMS OF NORMALIZED ENERGY USE TO EASILY SEE THE LINEAR PATH TO 50% REDUCTION/DOUBLING GOAL. WE CALCULATED THE NORMALIZED ENERGY USE FOR MOTORS BY TAKING THE LOSSES (1/EFFICIENCY - 1) AND THEN DIVIDING THE RESULT BY THE VALUE IN 2021 OR EARLIER. ONLY NATIONS WITH DATA ARE SHOWN.



ELECTRIC MOTOR MEPS

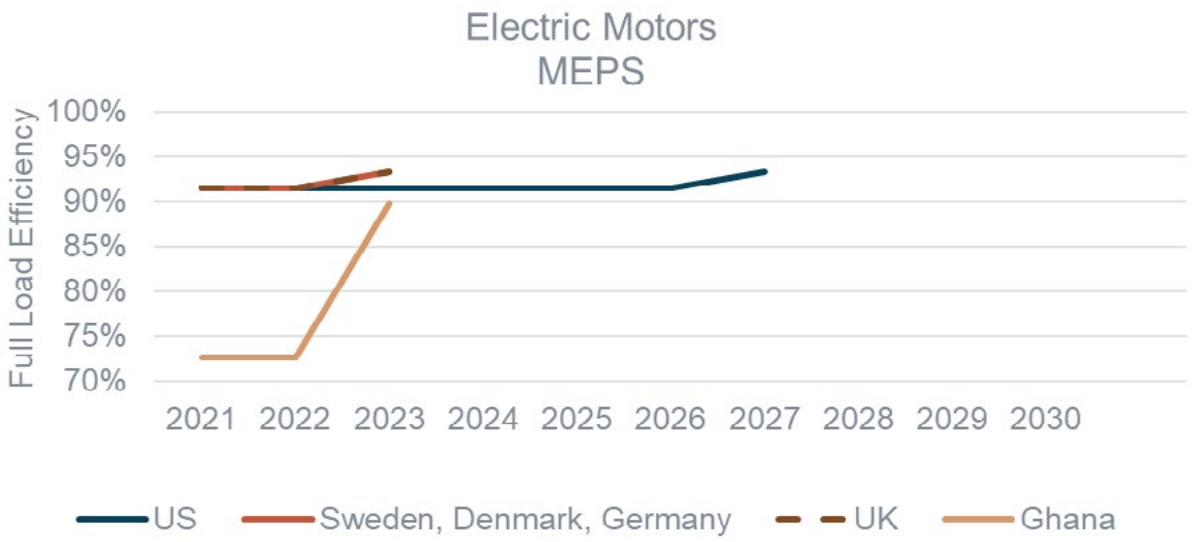
TABLE 5: STATUS OF ELECTRIC MOTOR MEPS

		CALL TO ACTION SIGNATORIES (15)	OTHER TOP EMITTERS (4)
MEPS Updates Support Doubling Efficiency by 2030		Denmark, Germany, Ghana, Sweden, United Kingdom	
MEPS Not on Track	MEPS Revisions Proposed		South Africa
	MEPS Recently Updated to World's Best MEPS (Future Revision Opportunity)		Canada, China, United States
	Weak or Technology-Specific MEPS Keeping Inefficient Products on the Market	Australia	
	Unknown or No MEPS	All Others	

Denmark, Germany, Sweden, and the UK have MEPS requiring IE4 for motors with output power 75-200 kW, as of July 2023 (IE3 for other output power capacities). These four nations (plus the rest of the EU and Switzerland) are the first to have a standard set at IE4. The US is following the EU's lead and will increase its motor MEPS from the current IE3 to IE4 for 75-200 kW motors by 2027.[28]

Furthermore, Ghana previously had no motor MEPS in place in 2021, but as of 2023, has MEPS set at IE2. For nations implementing MEPS for the first time, such as Ghana, we assumed a typical full-load efficiency 15 percentage points below IE1 (for example, 78% for a 75 kW motor). This is generally consistent with the typical efficiency of motors on the Ghanian market, estimated at 75%[29] (Figure 8).

FIGURE 8: NEW OR REVISED ELECTRIC MOTOR MEPS REQUIREMENTS FOR 75 KW MOTORS, USING THE LOCAL EFFICIENCY METRIC. ONLY NATIONS THAT HAVE MEPS TAKING EFFECT SINCE 2021 ARE SHOWN.



LOOKING AHEAD

As we recommended in World's Best MEPS[30]:

- All governments should align their motor MEPS with U4E's model regulation and require a minimum efficiency level of IE3.
- If nations already use the IE3 standard, they should adopt MEPS for additional components, such as variable speed drives (VSDs) or industrial air compressors, fans, and pumps.
- Finally, policymakers should strive to increase their standard to IE4 or IE5. IE5 motors using a synchronous reluctance design require VSDs, which allow for slower operation to meet partial loads, resulting in 9-29% energy reduction for common loads.[31]

Split Air Conditioners

Residential single-split and window air conditioners are included in the Call to Action. For our analysis, we only looked at split systems, which consist of an outdoor condenser paired with an indoor air handler, which is either ducted or ductless. These are the most common residential air conditioners worldwide. In line with the World's Best MEPS Report, we used the 2-ton/7kW system as our representative unit, but typical capacities will vary from nation to nation.[32]

SPLIT AIR CONDITIONER AVERAGE EFFICIENCY ON THE MARKET

The overall efficiency of the air conditioner market shows little progress. Despite there being some improvement in certain nations, there have also unfortunately been instances of a decrease in efficiency in others.

FIGURE 9: AVERAGE EFFICIENCY ON THE MARKET FOR SPLIT AIR CONDITIONERS USING THE LOCAL EFFICIENCY METRIC. ONLY NATIONS WITH DATA ARE SHOWN.

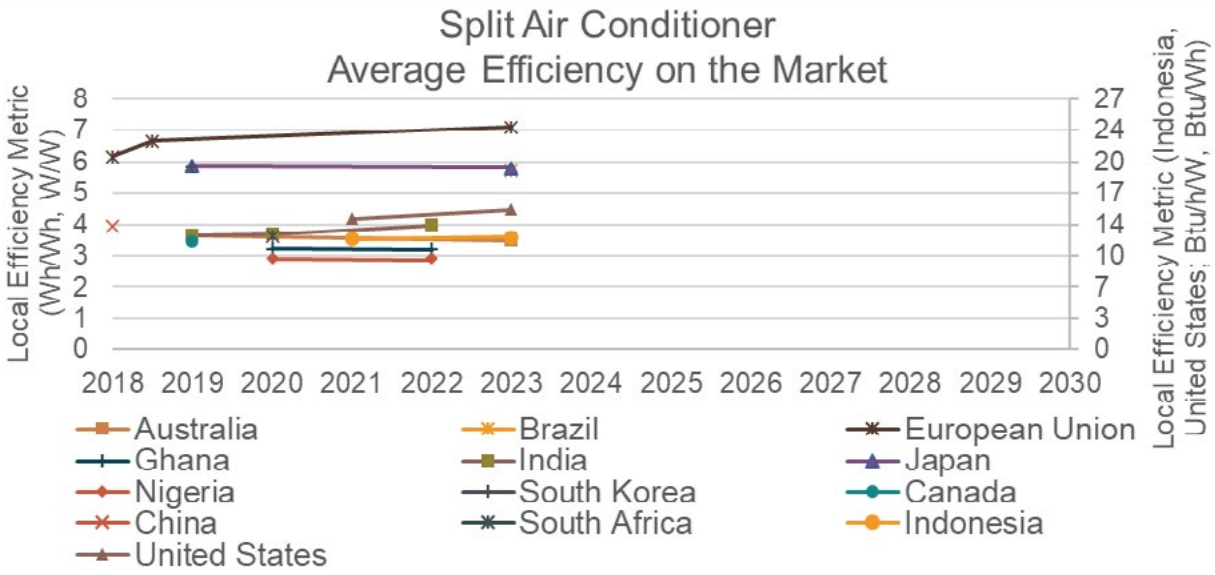
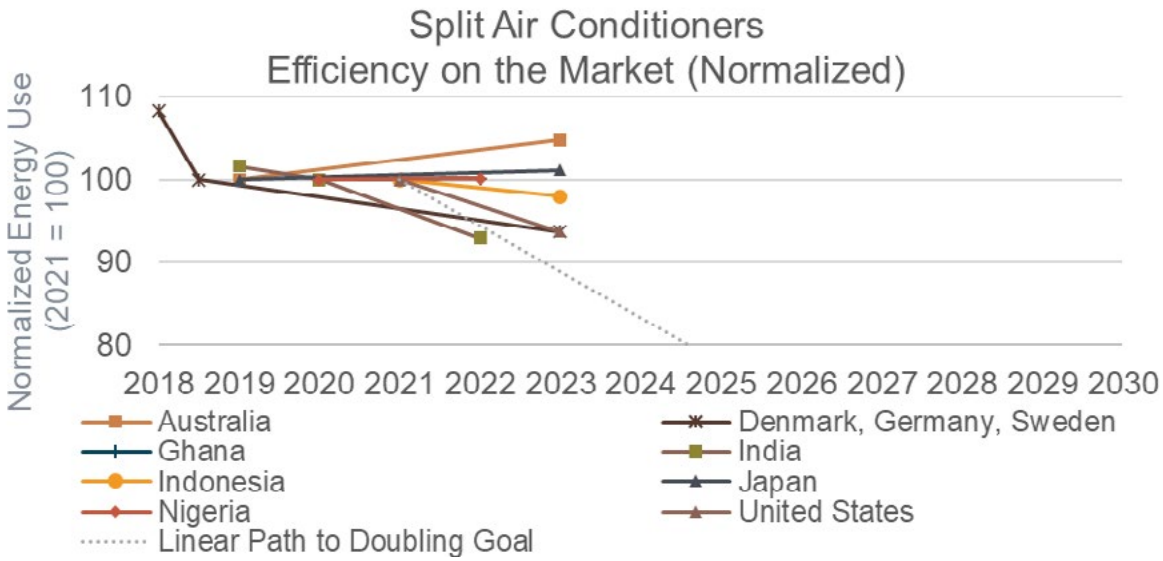


FIGURE 10: AVERAGE EFFICIENCY ON THE MARKET FOR SPLIT AIR CONDITIONERS EXPRESSED IN TERMS OF NORMALIZED ENERGY USE TO EASILY SEE THE LINEAR PATH TO 50% REDUCTION/DOUBLING GOAL. WE CALCULATED THE NORMALIZED ENERGY USE FOR AIR CONDITIONERS BY TAKING THE INVERSE OF THE EFFICIENCY AND THEN NORMALIZED BY DIVIDING THE RESULT BY THE VALUE IN 2021 OR EARLIER. ONLY NATIONS WITH DATA ARE SHOWN.



SPLIT AIR CONDITIONER MEPS

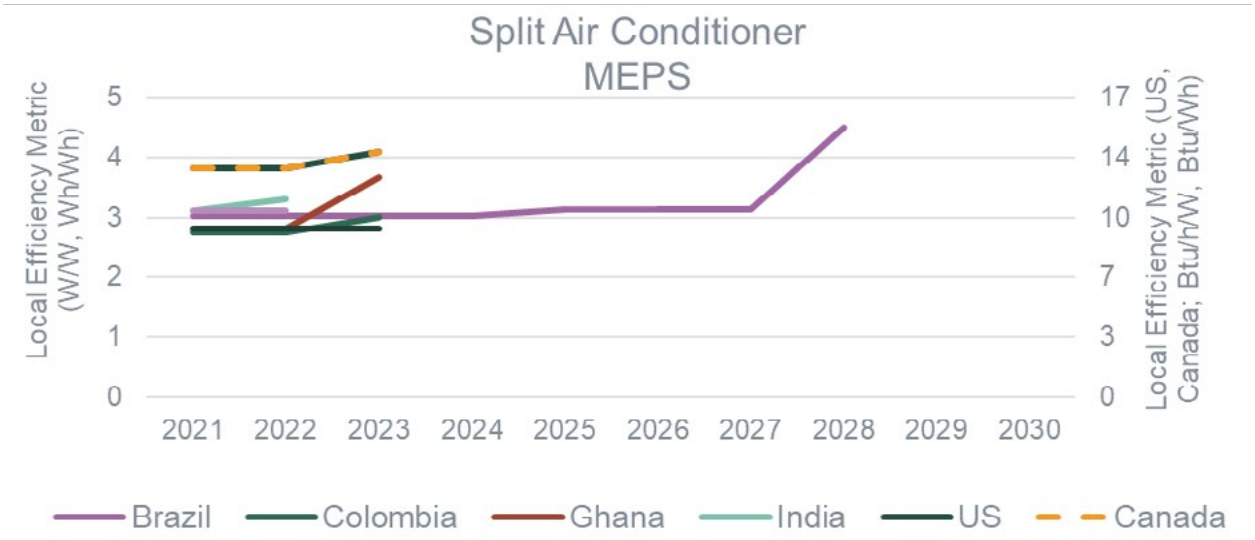
TABLE 6: STATUS OF SPLIT AIR CONDITIONER MEPS

		CALL TO ACTION SIGNATORIES (15)	OTHER TOP EMITTERS (4)
MEPS Updates Support Doubling Efficiency by 2030		Ghana	
MEPS Not on Track	MEPS Revisions Proposed		
	MEPS Recently Updated to World's Best MEPS (Future Revision Opportunity)		China
	Weak or Technology-Specific MEPS Keeping Inefficient Products on the Market	All Others	Canada, South Africa, United States
	Unknown or No MEPS	Japan (Top Runner only), Panama	

Every nation analyzed in this report has some form of AC MEPS in place. Ghana is the only one to have made ambitious updates recently, increasing the efficiency of its MEPS by 31% between 2022 and 2023. Most others have weak MEPS with small updates, or are otherwise keeping technology-specific MEPS, which are inhibiting progress toward higher efficiency products.

In the case of ACs, technology-specific MEPS involve using energy efficiency ratio (EER) as a metric, which requires testing at full load and fails to fully recognize the benefits of variable-speed ACs. Nearly all the Call to Action signatories have MEPS below what CLASP has defined to be as ambitious (6.1 Wh/Wh). This target is aligned with the current minimum standard in U4E's model regulation and with the MEPS in China.[33]

FIGURE 11: NEW OR REVISED RESIDENTIAL SPLIT AC MEPS REQUIREMENTS FOR 7.5 KW UNITS, USING THE LOCAL EFFICIENCY METRIC. ONLY SIGNATORIES THAT HAVE MEPS TAKING EFFECT SINCE 2021 ARE SHOWN.



LOOKING AHEAD

As we recommended in World's Best MEPS[34]:

- All governments should align their standards with U4E's guidelines. For example, they should adopt MEPS of ISO CSPF 6.1 Wh/Wh for 3.5 kW/1 ton cooling-only units. These levels are already in place in China and should serve as a template for the many nations that import Chinese ACs. Regional economic groupings are also making progress on setting levels for room Acs, including in ASEAN, where the ASEAN Regional Policy Roadmap for Energy Efficient Room Air Conditioners set MEPS levels at ISO CSPF 6.09 Wh/Wh by 2025.
- Governments that are still using an EER should switch to a seasonal performance metric for both fixed and variable-speed ACs in alignment with ISO standard 16358 and the U4E model regulation.
- The U4E model regulation for cooling-only ACs follows the requirements listed in Table 7 and Table 8, below.[35]

TABLE 7: U4E MODEL REGULATIONS FOR COOLING-ONLY ACS

CAPACITY	REQUIREMENT (ISO CSPF WH/WH)
Capacity ≤ 4.5kW	6.1
4.5kW < Capacity ≤ 9.5kW	5.1
9.5kW < Capacity ≤ 16kW	4.5

TABLE 8: U4E MODEL REGULATIONS FOR REVERSE-CYCLE ACS (PERFORM BOTH COOLING AND HEATING AND CONSTITUTE THE MAJORITY OF GLOBAL SALES DUE TO ALMOST UNIVERSAL PENETRATION OF REVERSE-CYCLE IN THE CHINA AND JAPAN AC MARKET[36]).

CAPACITY	REQUIREMENT (ANNUAL PERFORMANCE FACTOR [APF] WH/WH)
Capacity ≤ 4.5kW	5.0
4.5kW < Capacity ≤ 9.5kW	4.0
9.5kW < Capacity ≤ 16kW	3.6

Refrigerator-Freezers

Residential refrigerators, refrigerator-freezers, and freezers are included in the Call to Action. For our analysis, we focused on residential refrigerator-freezers with a total volume of 400 L. As the range of refrigerator sizes varies greatly, 400 L was chosen as a compromise in World's Best MEPS, and we have retained it here.

In contrast to the other products, which are evaluated in terms of efficiency (higher is better), refrigerators are typically evaluated in terms of energy consumption (lower is better).

REFRIGERATOR-FREEZER AVERAGE EFFICIENCY ON THE MARKET

Despite a lack of progress on MEPS, residential refrigerators are the only product in this analysis that has shown progress on efficiency in the market, with average efficiency improving in recent years. This provides an opportunity for governments to continue driving efficiency by revising MEPS with ambitious targets.

FIGURE 12: AVERAGE EFFICIENCY ON THE MARKET FOR REFRIGERATOR-FREEZERS USING THE LOCAL EFFICIENCY METRIC. ONLY NATIONS WITH DATA ARE SHOWN.

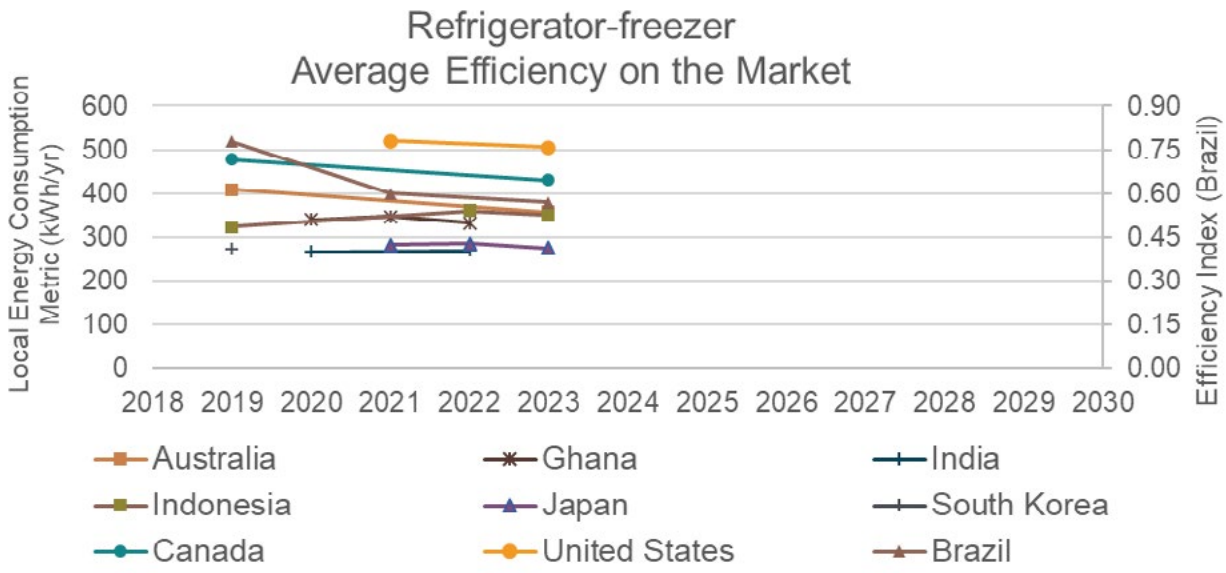
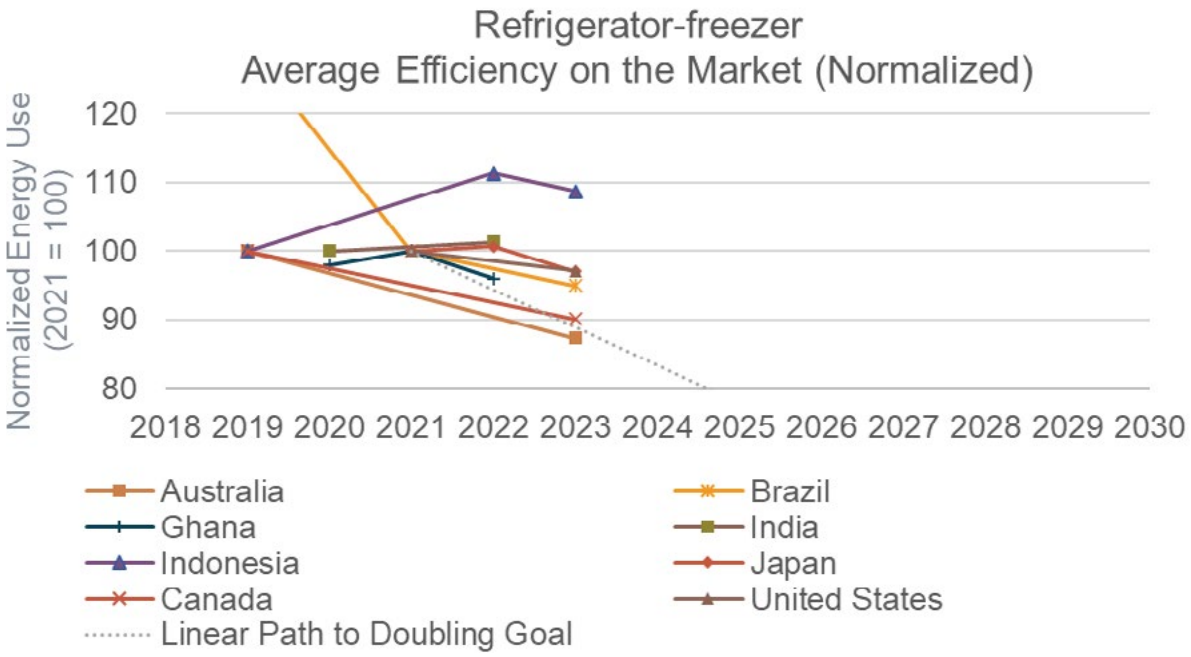


FIGURE 13: AVERAGE EFFICIENCY ON THE MARKET FOR REFRIGERATOR-FREEZERS EXPRESSED IN TERMS OF NORMALIZED ENERGY USE TO EASILY SEE THE LINEAR PATH TO 50% REDUCTION/DOUBLING GOAL. WE CALCULATED THE NORMALIZED ENERGY USE FOR REFRIGERATOR-FREEZERS BY DIVIDING ENERGY CONSUMPTION OR INDEX BY THE VALUE IN 2021 OR EARLIER. ONLY NATIONS WITH DATA ARE SHOWN.

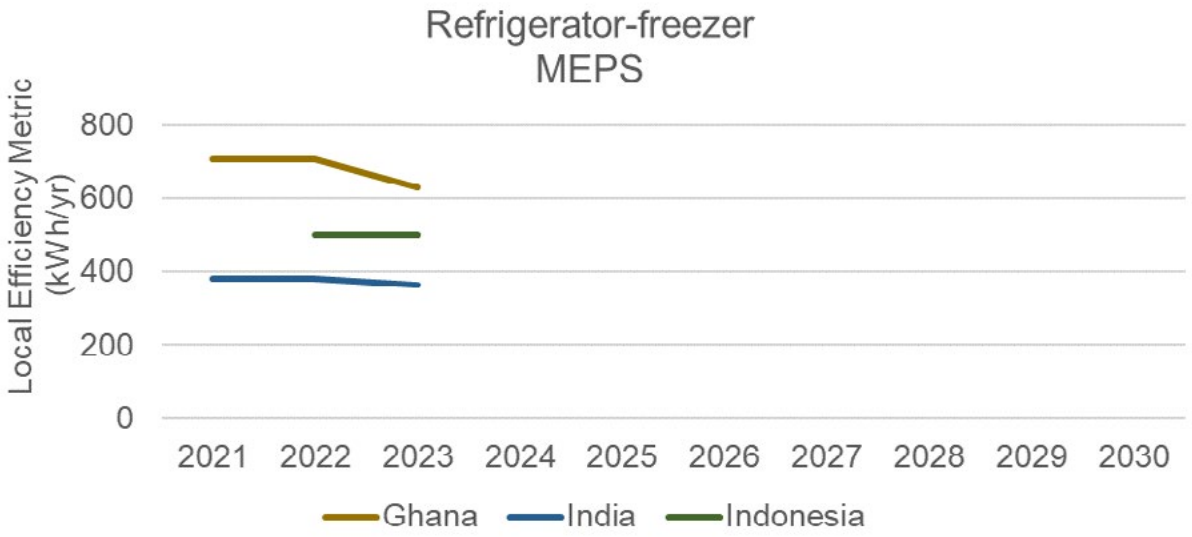


REFRIGERATOR-FREEZER MEPS

TABLE 9: STATUS OF RESIDENTIAL REFRIGERATOR-FREEZER MEPS

		CALL TO ACTION SIGNATORIES (15)	OTHER TOP EMITTERS (4)
MEPS Updates Support Doubling Efficiency by 2030			
MEPS Not on Track	MEPS Revisions Proposed		United States
	MEPS Recently Updated to World's Best MEPS (Future Revision Opportunity)		Canada
	Weak or Technology-Specific MEPS Keeping Inefficient Products on the Market	All Others	China, South Africa
	Unknown or No MEPS	Japan (Top Runner only)	

FIGURE 14: NEW OR REVISED RESIDENTIAL REFRIGERATOR-FREEZER MEPS REQUIREMENTS FOR 300 L FRESH/100 L FROZEN UNITS, USING THE LOCAL EFFICIENCY METRIC. ONLY SIGNATORIES THAT HAVE MEPS TAKING EFFECT SINCE 2021 ARE SHOWN.



The 400 L unit is not representative for the three nations shown in Table 20, where refrigerators are smaller, so typical MEPS levels will be lower than shown, and average energy consumption will be lower still. For example, in 2022, Ghana's average medium refrigerator-freezer (341–540 L) consumed an average 411 kWh, while the average 340 L refrigerator-freezer consumed 298 kWh.

Ghana is the only nation to make progress in line with the 2030 doubling target, increasing the efficiency of its MEPS by 10% between 2022 and 2023. India also revised its MEPS, while Indonesia implemented a new MEPS in 2022 (hence no comparison in 2021). Beyond that, there have been no other recent revisions.

However, nearly half of the top-emitting nations analyzed in World's Best MEPS had MEPS meeting the U4E's model regulation level of 279 kWh/year for a 400 L unit, tested under an average of 16 and 32 °C.[37] Despite meeting this target, there is still room for further improvement, such as embracing the intermediate or high levels of the U4E model regulations. For example, the US has proposed a new standard that will reduce the annual consumption for the 400 L unit by 15% by 2027.

LOOKING AHEAD

As we recommended in World's Best MEPS[38]:

- All governments should align with the U4E model regulations and enforce a maximum annual energy consumption of 279 kWh for a 400 L frost-free refrigerator-freezer at an average of 16 and 32°C.[39] Those that have already adopted MEPS at that level should work to increase the stringency of their standards to U4E's intermediate tier, which requires an annual energy consumption no greater than 223 kWh for a 400 L unit at an average of 16 and 32 °C.[k]

[k] Requirements should be scaled appropriately to each nation's sizes and test conditions.

Conclusion

The world needs to move faster to achieve energy efficiency commitments. CLASP identified moments of initial progress toward the Call to Action goal by signatories and other top-emitting nations, but overall we found an urgent need for much greater action.

The following table reflects the state of progress for each appliance analyzed:

TABLE 10: STATES OF PROGRESS FOR EACH APPLIANCE

APPLIANCE	WHO IS ON TRACK	INTERVENTIONS IMPLEMENTED
General Service Lamps	Unknown	Signatories ■ Chile doubling MEPS to 85 lm/W by 2026 ■ UK proposed MEPS at 140 lm/W by 2024 ■ Other Top Emitters ■ South Africa doubling MEPS to 90 lm/W by 2024 and 124 lm/W by 2026 ■ US proposed MEPS at 124 lm/W by 2029
Electric Motors	**0 on track** **3 not on track**	Signatories ■ Denmark, Germany, Sweden, United Kingdom adopted MEPS at IE4 for 75-200 kW by July 2023 ■ Ghana adopted MEPS at IE2 by 2023 ■ Other Top Emitters ■ US adopted MEPS at IE4 for 75-200 kW by July 2027 ■ South Africa proposed MEPS at IE3
Split Air Conditioners	**1 on track: India** **7 not on track**	Signatories ■ Ghana adopted MEPS increasing minimum efficiency by 31% in 2023 ■ Other Top Emitters ■ US and Canada adopted incremental MEPS in 2023
Refrigerator-freezers	**1 on track: Australia** **5 not on track**	Signatories ■ Ghana, India, and Indonesia all recently adopted MEPS ■ Other Top Emitters ■ US proposed MEPS for adoption by 2027

Despite the lack of progress on the average efficiency of products on the market, several nations have been updating their MEPS. Some signatories and other top emitters have achieved or are proposing large increases in the minimum efficiencies required. Global conventions provide an additional path to action, such as for those signatories that are also a party to the Minamata Convention on Mercury and will be required to eliminate CFLs starting in 2025.

We expect these MEPS changes to be reflected in the efficiency of products on the market in the future; however, given the limited progress in the two years since COP26, the signatories and other nations committed to reducing appliance energy consumption should renew their efforts and adopt policies in line with the doubling goal. For some governments and products, doubling the stringency of MEPS is possible today, as we saw in the case of Chile on lighting (from 40 lm/W to 85 lm/W). For other nations that are already at or close to the world-leading levels outlined in World's Best MEPS, doubling may require several steps.

Additionally, to confirm that a doubling in MEPS stringency achieves the desired doubling in efficiency of products on the market, governments should track product efficiency through product databases (for example in the EU, Japan, and Korea) and market research. All product types and technologies with a significant market share should be tracked, especially for lighting.

The upcoming COP28 in November 2023 in Dubai offers an opportunity for signatories to take stock of their progress, renew their commitments to the doubling goal, and increase tracking. It is also an opportunity for other top emitters that have not yet signed onto the Call to Action to do so. In addition to the signatories, we analyzed the progress of four top emitters: China, Canada, South Africa, and the United States. All four nations are revising or developing new MEPS, with some recent MEPS on track to lead to doubling in 2030 if continued at the same pace. We will continue tracking progress and encourage all governments to commit to doubling the efficiency of appliances as a necessary step toward Net Zero!

Appendix A:
Technical Appendix

GENERAL SERVICE LAMPS

In 2022, the Australian government released proposals for an LED regulation at 90 lm/W, and a separate upgrade to efficiency regulations for most tungsten filament and halogen lamps that would result in the elimination of almost all products.[40]

Australia does not have technology neutral MEPS in place for lighting. As a result, its incandescent standards provide a floor of 14.7 W for an 800 lm bulb.[41]

There was no available data on the energy efficiency of all types of lighting in Australia. There were individual product databases for incandescent and CFLs,[42] but no market data for LEDs.

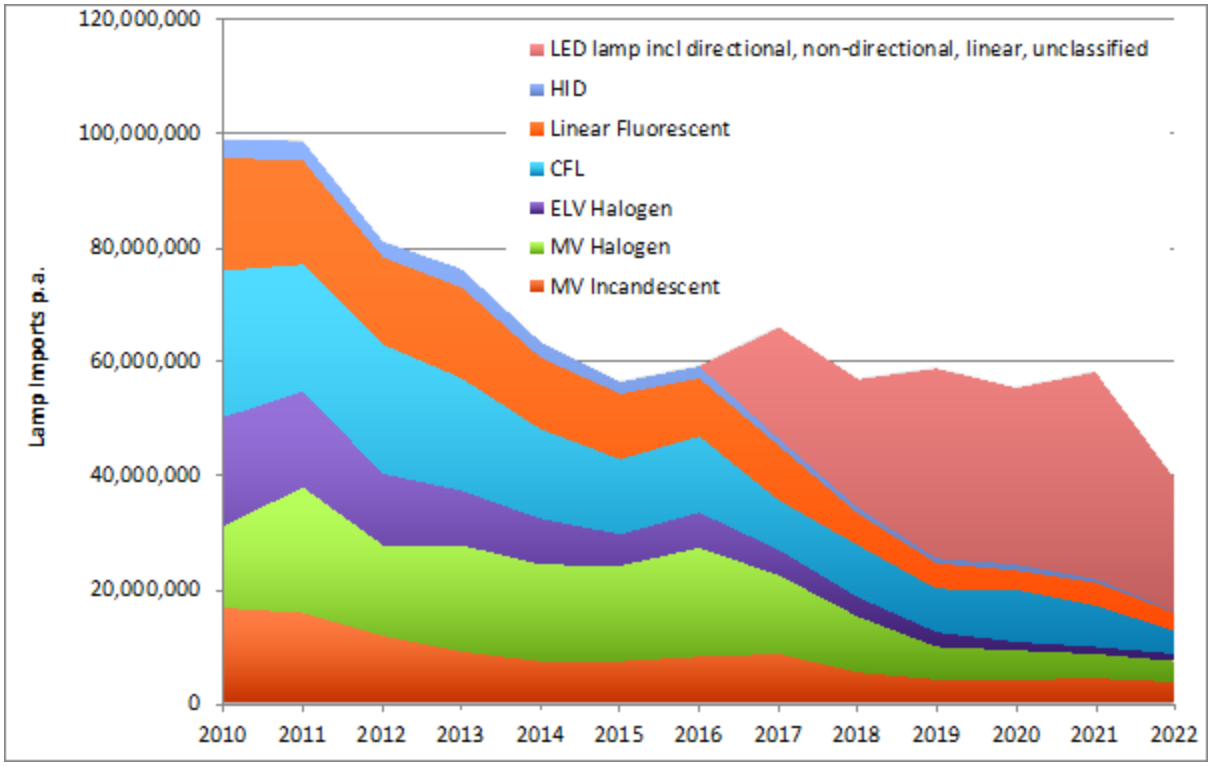
Nonetheless, we expect LEDs to outnumber incandescents and CFLs due to LEDs' growing imports into Australia, as seen in Figure 15, and longer lifetime.

ELECTRIC MOTORS

Australia introduced MEPS for electric motors in 2001. These were upgraded in 2006 and were aligned to IE2 levels in 2019.[44] At this stage, there are no formal proposals to increase the efficiency levels for motors, although a range of investigations are under way. The policy is listed as "In Force" on the Australian Government website and no other regulations are listed on the Federal Register of Legislation "Series Page"; therefore, we concluded there have been no updated standards since.[45]

To evaluate progress on efficiency of the typical product in the market, we compared the simple average of energy efficiency percentage at full load across the four size categories in the PEET analysis: 2.2 kW +/- 5%, 7.5 kW +/- 5%, 20 kW +/- 5%, and 75 kW +/- 5%. However, there are no 20 kW motors in the database or in IEC standard 60034-30-1, so we believe that to be an error and changed it to 22 kW, which continues the pattern for the other size categories. The

FIGURE 15: HISTORICAL SALES OF LAMPS BY TYPE IN AUSTRALIA.[43]



average efficiency in 2019 was 91%,[46] while the same analysis, recreated using models listed in the 2023 Australian database marked as "Available" and sold in Australia, revealed the same average efficiency at a full load of 91%.[47]

SPLIT AIR CONDITIONERS

In 2019, Australia's MEPS requirement for a Product Class 8 air-to-air single-split, non-ducted, <4kW unit was 3.66 Annual EER.[48] This requirement took effect in 2020. There has been no updated standard since, but a recent internal benchmarking comparison found that local MEPS levels for split systems up to 10kW were equivalent to the U4E recommendations for reverse cycle units.[49]

To evaluate progress on efficiency of the typical product in the market, we compared the simple average of EER across four size categories: 2 kW +/- 5%, 3.5 kW +/- 5%, 5 kW +/- 5%, and 7 kW +/- 5%. The average in 2019 was 3.65 W/W,[50] while the same analysis, recreated using models listed in 2023 and marked as "Available" and sold in Australia, revealed an average EER across the four categories of 3.48 W/W.[51]

REFRIGERATOR-FREEZERS

MEPS for this product were first introduced in 1999, with upgrades in 2005 (based on US 2000 levels) and 2021 (based on US 2014 levels). Mandatory energy labeling started in the 1980s, with label re-grades in 2000, 2010, and 2021. The current requirements are specified in the Greenhouse and Energy Minimum Standards (Household Refrigerating Appliances) Determination 2019.

To evaluate progress on MEPS, we reviewed the Federal Register of Legislation for standards for household refrigerating appliances.[52] The only standard listed was adopted on 7 August 2019, with an effective date two years later (prior to COP26). It is still listed as "In Force", so we can conclude that there are no updates.

To evaluate progress on efficiency of the typical product in the market, we compared the simple average of annual energy consumption across four size categories: 150 L +/- 5%, 450 L +/- 5%, 750 L +/- 5%, and 1000 L +/- 5%. The average in 2019 was 409 kWh,[53] while the same analysis recreated using models listed in 2023 and marked as "Available" and sold in Australia, revealed average energy consumption across the four categories of 357 kWh.[54] We calculated a new internationally-comparable adjusted volume by multiplying the frozen volume first by 2.15 then by 1.2, assuming that all freezers have automatic defrost.[55] We did not adjust/normalize the energy consumption, and instead compared local unit energy consumption (UEC) between 2019 and 2023.

Brazil

GENERAL SERVICE LAMPS

Brazil does not have technology neutral MEPS in place; they only have standards in place for CFLs (56 lm/W).[56] In Brazil, CFL, incandescent, and high intensity discharge (HID) lighting standards are overseen by the Ministry of Mines and Energy (MME), and they are making slow progress in improving lighting regulations. This is in part because MEPS revision in Brazil typically follows label revisions, which are managed by a separate government institution: Inmetro. CLASP is currently working with Inmetro to enhance lighting policies, and we anticipate further progress in lighting regulation from the MME once there are updates on labeling from Inmetro.[l]

There was no available historic or present data on the efficiency of Brazil's lighting market that encompasses all types of lighting.

ELECTRIC MOTORS

As of 2019, Brazil implemented a MEPS of IE3 for their electric motors.[57] There has been no updated standard since. Brazilian manufacturers and policymakers have reported that motor MEPS revisions are not currently on their priority list. Instead, they are more focused on motor replacement. This means replacing rewind motors that are currently used in the market, with those that meet the IE3 standard. Moreover, there is a potential possibility to establish standards for pumps, fans, and other motor components under their MEPS, which will increase their standards stringency in a different way.[m]

There was no historic or present data on the efficiency of Brazil's electric motor market.[n]

[l] CLASP expert opinion.
[m] CLASP expert opinion.
[n] It is worth noting that while this data is not currently available, GIZ is conducting a study on Brazil's motor market.

SPLIT AIR CONDITIONERS

Since 2020, Brazil has had a MEPS of 3.02 ISO CSPF (Wh/Wh) for their split-system ACs.[58] This standard is still in force today, but there are a series of future tiers in place. In 2025, MEPS will be increased to 3.14 ISO CSPF, and in 2028, up to 4.5 ISO CSPF.[59]

To evaluate progress on efficiency of the typical product in the market, we compared the simple EER of all products with a registration date within 11 years of the most recent year. The reasoning for this was that the 2023 data only included products with a registration that date back to 2012, whereas the 2018 data had models that date back to 2004. To standardize between the two datasets, we chose to analyze the same year range length. The average efficiency in 2018 (looking at models between 2007-2018) was 3 EER (W/W).[o] The average efficiency in 2023 (looking at models between 2012-2023) was 5.7 EER (W/W).[60]

REFRIGERATOR-FREEZERS

As of 2018, Brazil implemented a MEPS for refrigerator-freezers. There has been no updated standard since. It should be noted that the Ministry of Mines and Energy (MME) is currently in the process of improving their refrigerator MEPS.

To evaluate progress on efficiency of the typical product in the market, we looked at the simple average of the energy efficiency index (c/cp). This energy efficiency index is calculated by dividing each product's monthly electricity consumption by the "standard consumption" for a product of that size and type. There are different equations for standard consumption depending on whether a product is a refrigerator, a refrigerator-freezer, or a vertical or horizontal freezer. Additionally, for combined refrigerator-freezers and vertical freezers, there are separate equations depending on whether the product has manual or automatic defrost. In each case, the equation has the format of "Standard Consumption = a x Adjusted Volume + b", where "a" and "b" vary by product type.[61]

In 2019, the average efficiency index was 0.78, or 78%.[p] To calculate the average for 2023, we filtered for models with /2023, /2022, and /2021 in the registration number to isolate the past three years of models, resulting in an average efficiency index of 0.57, or 57%. Finally, we repeated this analysis for 2021, using the current database, but filtering for models with /2021, /2020, and /2019 in the registration number, resulting in an average index of 0.60, or 60%.[62] We used the average of efficiency index values at 127 V, or at 220 V if data at 127 V was not available (this ensured that we used all the data available, but that each model was only included once; there was not much difference in results between the two voltages).

Canada

GENERAL SERVICE LAMPS

As of 2014, Canada implemented a technology neutral lighting MEPS of 15 lm/W. While there has been no updated standard since,[63] there is a proposal to increase stringency to 45 lm/W on January 1, 2024.[64]

There was no comprehensive historic or present data on the efficiency of Canada's indoor lighting market. Canada's lighting products are regulated piecemeal and use different standardizing units, making it difficult to calculate an average efficiency across all domestic lighting products.

ELECTRIC MOTORS

As of 1 June 2016, Canada implemented a MEPS of IE3 for electric motors.[65] There has been no updated standard since.

To evaluate progress on efficiency of the typical product in the market, we compared the simple average of energy efficiency percentage at full load across the four size categories in the PEET analysis: 2.2 kW +/- 5%, 7.5 kW +/- 5%, 20 kW +/- 5%, and 75 kW +/- 5%. However, there are no 20 kW motors in the database or in IEC standard 60034-30-1, so we believe that to be an error and changed it to 22 kW, which continues the pattern for the other size categories. The average efficiency in 2019 was 93%,[66] while the same analysis recreated using models listed in the 2023 Canadian database revealed an average efficiency at full load of 92%.[67]

[o] Based on CLASP data.
[p] Based on CLASP data.

SPLIT AIR CONDITIONERS

In 2017, Canada implemented a MEPS of 13 US seasonal energy efficiency ratio (SEER) (Btu/Wh).[68] As of 1 January 2023, Canada has a new standard in place at 14 US SEER (Btu/Wh).[69] This has resulted in an 8% increase in efficiency. The new standard is expressed in terms of SEER2, but we listed the old metric here to enable easier comparison.

There was no historic or present data on the efficiency of Canada's AC market. In particular, the split air conditioner product list was empty at the time of research, perhaps due to the recent standard transition.[70]

REFRIGERATOR-FREEZERS

To evaluate progress on MEPS, we reviewed the Energy Efficiency Regulations page, which says regulations were last updated on 15 September 2014.[71]

To evaluate progress on efficiency of the typical product in the market, we compared the simple average of EER across four size categories: 150 L +/- 5%, 450 L +/- 5%, 750 L +/- 5%, and 1000 L +/- 5%. The average in 2019 was 477 kWh,[72] while the same analysis, recreated using models listed in 2023, revealed average energy consumption across the four categories as 430 kWh.[73] As explained in the 4E PEET methodology document, we calculated a new internationally-comparable adjusted volume by multiplying the frozen volume first by 2.15 then by 1.2, assuming that all freezers have automatic defrost.[74] We did not adjust the energy consumption, but rather compared local UECs between 2019 and 2023.

Chile

GENERAL SERVICE LAMPS

In 2021, Chile had a MEPS of 40 lm/W for their indoor lighting products. In 2023, this standard increased to 70 lm/W, and in 2025, it is scheduled to increase to 85 lm/W.[75] This reflects a 113% increase in efficiency between 2021 and 2025.

ELECTRIC MOTORS

Chile currently has no MEPS in place for their electric motors.[76]

SPLIT AIR CONDITIONERS

In 2018, Chile adopted a MEPS of 3.2 energy efficiency index (IEE) for ACs.[77] There has been no updated standard since.

REFRIGERATOR-FREEZERS

In 2014, Chile adopted MEPS for refrigerators.[78] There has been no updated standard since.

China

GENERAL SERVICE LAMPS

China does not have any technology neutral MEPS for indoor lighting.

There was no historic or present data on the efficiency of China's indoor lighting market.

ELECTRIC MOTORS

As of 1 July 2021, China has a MEPS of IE3 in place for their electric motors.[79] There has been no updated standard since.

There was no historic or present data on the efficiency of China's electric motors systems market.

SPLIT AIR CONDITIONERS

As of 2020, China's cooling-only product has a MEPS of 5 SEER. China's heating and cooling products have a MEPS of 4 APF.[80] There has been no updated standard since.

While there was efficiency data from both 2018 and 2021, the data sources used different metrics (APF and EER) and therefore were not comparable for the sake of this analysis.

REFRIGERATOR-FREEZERS

There was no historic or present data on the efficiency of China's residential refrigerator market.

As of 2015, China implemented a refrigerator MEPS of 408 kWh/year.[81] There has been no updated standard since.

Colombia

GENERAL SERVICE LAMPS

There was no historic or present data on the efficiency of Colombia's indoor lighting market.

There are no technology neutral lighting MEPS in Colombia.

ELECTRIC MOTORS

There was no historic or present data on the efficiency of Colombia's electric motor market.

As of 2020, Colombia implemented a MEPS of IE3 for their electric motors systems.[82] There has been no updated standard since.

SPLIT AIR CONDITIONERS

There was no historic or present data on the efficiency of Colombia's air conditioners market.

Colombia had a MEPS of 2.75 CSPF in 2021 and updated their MEPS in 2023 to be 3.0 CSPF.[83]

REFRIGERATOR-FREEZERS

There appears to be a labeling regulation in place for refrigerators as of 2016, but no formal MEPS regulation in place according to the Ministry of Mines and Energy site.[84]

There was no historic or present data on the efficiency of Colombia's residential refrigerator market.

European Union (Denmark, Germany, and Sweden)

GENERAL SERVICE LAMPS

The EU has had a MEPS that requires 91 lm/W for a lamp with 800 lm light output for their indoor lighting products since 2021. To date, there has been no updated policy.[85]

We were unable to evaluate progress on efficiency due to lack of historical data. Current data from the EPREL database shows an average efficacy of 105 lm/W for an 800 lm +/- 5%, non-directional E27 (medium screw base) lamp, based on the mid-point of the labeling classes they belong to.

ELECTRIC MOTORS

In 2021, the EU had a MEPS of IE3 for their electric motor systems. As of 2023, some motors fall under a MEPS of IE4 (75 kW to 200 kW inclusive).[86] As these larger motors are expected to comprise the majority of the energy use, we considered the IE4 level the benchmark.

There was no historic or present data on the efficiency of the EU's electric motor market.

SPLIT AIR CONDITIONERS

As of 2014, the EU has a MEPS of 4.3 EU SEER for their air conditioners. There has been no updated standard since, but standards are currently under review.

To evaluate progress on efficiency of the typical product in the market, we reviewed a 2018 Ecodesign preparatory study that showed the average SEER for two capacity categories in the EU: 3.5 and 7.1 kW, with a simple average of 6.15 Wh/Wh.[87] A second analysis, based on "1300 AC models listed in June 2018 on the Eurovent Certification website", found an average SEER of 6.66.[88]

We compared this result to an average SEER calculation based on the distribution of labeling classes for 3.5 and 7.1 kW units in the present-day EPREL database.[89] As the database only reports the percentage of models in each labeling class, we assumed that all models in the class had a SEER equal to the midpoint of the class (e.g., for the A++ labeling class, which includes models between 6.1 and 8.5 Wh/Wh, we assumed a SEER of 7.3 Wh/Wh, which is the average of 6.1 and 8.5; however, for the A+++ labeling class, which includes models with SEER greater than or equal to 8.5 Wh/Wh, we conservatively assumed all ACs at 8.5 Wh/Wh). The resultant average SEER across the labeling classes was 7.12 Wh/Wh.

REFRIGERATOR-FREEZERS

The EU has a MEPS of 250 kWh/year for their residential refrigerators. There has been no updated standard since 2021.[90] A new MEPS level is scheduled to come into force on 1 March 2024, which will result in a 20% reduction on 2021 MEPS levels for most products.

There was no historic or present data on the efficiency of the EU's residential refrigerator market.

Ghana

GENERAL SERVICE LAMPS

To evaluate progress on MEPS, we reviewed the Ghana Energy Commission's list of Legislative Instruments.[91] Legislative Instrument 2353 from 2017 (implemented 2020) requires 50 lm/W for <= 4000 K, 6-25 W CFLs and LEDs. Legislative Instrument 1932 from 2008 (implemented in 2013) banned the sale of incandescents. A second, standalone Legislative Instrument (LI 2442) reaffirmed this ban in 2022.

There was no historic or present technology neutral data on the efficiency of Ghana's indoor lighting market.

ELECTRIC MOTORS

Legislative Instrument 2456 from 2022 (to be implemented in 2023)[92] requires IE2 levels for motors. There were no previous MEPS for motors.[93]

There was no historic or present technology neutral data on the efficiency of Ghana's electric motor market.

SPLIT AIR CONDITIONERS

To evaluate progress on MEPS, we reviewed the Ghana Energy Commission's list of Legislative Instruments,[94] which listed a MEPS for ACs at 2.8 W/W EER implemented in 2014, followed recently by another at 3.66 Annual Energy Efficiency Ratio (AEER), to be implemented in 2023.[95] AEER differs from EER as it includes 6,760 hours of inactive power for split systems; however, we do not expect this to make a significant impact (inactive power is much smaller than active power), so we compared the two directly.

To evaluate progress on efficiency of the typical product in the market, we analyzed the distribution of AC EERs found through CLASP's and the Institute of Governance and Sustainable Development's (IGSD) AC dumping study, collected in 2020.[96] The study published the share of models within each EER class; we ascribed the EER at the middle of the labeling class to all units within the labeling class (e.g., for the 3.5–4.0 EER class we assumed an EER of 3.75 W/W). The resultant weighted average EER was 3.21 W/W.

We compared this result to the average EER revealed through web scraping data for nine models from the Jumia e-commerce site for Ghana 28 June 2019–30 June 2022.[97] Despite the small sample size, the result was virtually unchanged at 3.20 W/W.

REFRIGERATOR-FREEZERS

To evaluate progress on MEPS, we reviewed Ghana Energy Commission's list of Legislative Instruments.[98] LI 1958, implemented in 2013, sets the lowest 1-star labeling tier at Efficiency Index (I) < 90 for the subtropical class.[99] While LI 2441, to be implemented in 2023, sets the lowest 1-star labeling tier at Energy Efficiency Index (EEI, a slightly different metric) < 85.[100] To evaluate progress, CLASP calculated the energy consumption of a frost-free, subtropical-class, refrigerator-freezer with a 300 L fresh food compartment and 100 L frozen food compartment that would just meet either metric, resulting in 705 kWh/yr today, and 628 kW/yr starting later in 2023.

To evaluate efficiency progress, we used data from the 2022 Ghana Energy Commission energy efficiency policy report.[101] In 2020, the average efficiency of residential refrigerators was 340 kWh/year; in 2021 it was 347 kWh/year, and in 2022 it was 333 kWh/year, half the MEPS requirement above. This shows there was an overall increase in efficiency between 2020 and 2022, despite a slight decrease in efficiency in 2021.

India

GENERAL SERVICE LAMPS

India does not have technology neutral MEPS for indoor lighting products; therefore, their MEPS were not analyzed in this report.

To analyze the transformation in efficiency of India's lighting market, we used data from CLASP's "Energy Efficiency Policies and Market Transformation in Lighting Industry".[102] This research provided a snapshot of the market shares of lighting products in 2020, as well as average efficiencies for CFLs, TFLs, LEDs, and ICLs (incandescent). We used the following market shares and calculated that the average sales-weighted efficiency of lighting products in 2020 as 58.4 lm/W (See Table 11 below).

ELECTRIC MOTORS

In 2021, India's motor MEPS were set at IE2 and there has been no updated policy to date.[104]

To evaluate progress on efficiency of the typical product in the market, we calculated the simple average of the product's efficiency based on their IE class. The data for both 2021 and 2022 provides the percentage breakdown of products in the market that either fall into IE3 + IE4 or IE2. Since IE3 and IE4 were grouped under one category, we assumed an even split between the two categories. For instance, in 2021, 12% of motors fell under the IE3 + IE4 category, so we assumed 6% were under each grouping. Using this methodology, we found that the average full load efficiency for an 11 kW, 4 pole motor in 2021 would be 90.1, and in 2022, would be 90.2.[105]

SPLIT AIR CONDITIONERS

India's AC MEPS was set at 3.1 ISEER in 2021. Starting in 2022, the new MEPS is 3.3 India Seasonal Energy Efficiency Ratio (ISEER).[q]

We were only able to find historic efficiency data on India's residential AC market in the Bureau of Energy Efficiency's (BEE) Impact Reports. We used the shares of fixed and variable-speed air conditioners at each star level and multiplied them by the average ISEER in each star category as follows below in Tables 12, 13, and 14.

TABLE 11: INDIA LIGHTING MARKET SHARE BY TECHNOLOGY IN 2020.[103]

	LEDS	CFL	FTL	ICL
Market Share	**56%**	**1%**	**6%**	**37%**

Note: There was no more recent data across all the lighting technologies.

TABLE 12: HISTORICAL EFFICIENCY DISTRIBUTION OF ACS IN INDIA (PERCENTAGE AND TOTAL SHIPMENTS) [FISCAL YEAR 2018-2019).[106]

	5 STAR SHARE (%)	4 STAR SHARE (%)	3 STAR SHARE (%)	2 STAR SHARE (%)	1 STAR SHARE (%)	TOTAL SHIPMENTS
Variable Speed	**21**	**5**	**74**	**0**	**0**	**3,924,884**
Fixed Speed	**4.7**	**0.9**	**77.4**	**14**	**3**	**3,304,280**

[q] Latest Notice (Nov 10, 2021), extended 1st tier of requirements through 30 June 2022, and second tier through 31 December 2024".

TABLE 13: CURRENT EFFICIENCY DISTRIBUTION OF ACS IN INDIA (FISCAL YEAR 2021-2022).[107]

	5 STAR	4 STAR	3 STAR	2 STAR	1 STAR
Variable Speed	**1,939,753**	**703,928**	**3,076,556**	**29,627**	**50**
Fixed Speed	**192,946**	**25,920**	**2,155,478**	**135,564**	**34,089**

TABLE 14: MINIMUM EFFICIENCY FOR EACH AC STAR RATING CATEGORY.[108]

	5 STAR	4 STAR	3 STAR	2 STAR	1 STAR
Minimum ISEER in Category	**4.5**	**4.245**	**3.745**	**3.395**	**3.195**

REFRIGERATOR-FREEZERS

As of 2021, India has a MEPS that would require 280 kWh/year for a 400 L (510 L adjusted volume) frost-free refrigerator, when normalized to an average of 16 and 32 °C per the methodology in World's Best MEPS (India test standard defines test only at 32 °C).[109] In 2023, the MEPS have been updated, resulting in an annual energy consumption of 263 kWh/year under the same assumptions.[110] Without the scaling, the requirements were 381 kWh/year in 2021 and 362 kWh/year in 2023.

Similar to split air conditioners, we were only able to find historic efficiency data on India's refrigerator market in the BEE Impact Reports. We used the shares of frost free and direct cool at each star level, and multiplied them by the average ISEEER in each star category as follows:

TABLE 15: HISTORICAL EFFICIENCY DISTRIBUTION OF REFRIGERATORS IN INDIA (PERCENTAGES AND TOTAL SHIPMENTS) (FISCAL YEAR 2018-2019 AND 2019-2020).[111]

	5 STAR SHARE (%)	4 STAR SHARE (%)	3 STAR SHARE (%)	2 STAR SHARE (%)	1 STAR SHARE (%)	TOTAL SHIPMENTS
Frost Free	**0**	**1.5**	**29.428**	**56.472**	**12.6**	**3,074,275**
Direct Cool	**3**	**18.3**	**28.2**	**35.8**	**14.7**	**11,998,899**

TABLE 16: CURRENT EFFICIENCY DISTRIBUTION OF ACS IN INDIA (FISCAL YEAR 2021-2022).[112]

	5 STAR	4 STAR	3 STAR	2 STAR	1 STAR
Variable Speed	**0**	**4,018**	**1,053,457**	**2,240,680**	**36,308**
Direct Cool	**559,570**	**852,020**	**3,530,429**	**2,799,352**	**1,877,968**

TABLE 17: STAR RATINGS (ANNUAL ENERGY CONSUMPTION FOR THE SPECIFIED ADJUSTED VOLUME, NORMALIZED TO AN AVERAGE OF 16 AND 32 °C TEST CONDITIONS, AS IN WORLD'S BEST MEPS).[113]

	5 STAR	4 STAR	3 STAR	2 STAR	1 STAR
Frost Free (510L adjusted volume)	**161.67**	**201.46**	**252.33**	**315.28**	**394.86**
Direct Cool (250L adjusted volume)	**145.08**	**181.85**	**227.19**	**284.61**	**355.64**

Indonesia

GENERAL SERVICE LAMPS

Indonesia adopted MEPS for indoor LED lamps at 80 lm/W in 2021 and effectively implemented in 2022. In addition, Indonesia is committed to banning CFLs by 2025 per the Minamata Convention. Unfortunately, there is no plan yet for banning incandescent lamps. Since there were no MEPS prior to the Call to Action and no revisions since 2022, it is not possible to track progress. In addition, a regional lighting roadmap in Southeast Asia sets MEPS levels at a minimum of 80 lm/W by 2023, which has to be implemented in Indonesia (beyond LED lighting).

There was no historic or present technology neutral data on the efficiency of Indonesia's indoor lighting market.

ELECTRIC MOTORS

Indonesia does not have MEPS for electric motors or other system components, and no efficiency data were available. However, Indonesia is currently planning to evaluate MEPS in 2024.

There was no historic or present data on the efficiency of Indonesia's electric motor market.

SPLIT AIR CONDITIONERS

Indonesia adopted revised MEPS for ACs in August 2021 at 3.10 Wh/Wh CSPF; however, these were not an increase in stringency. Rather, they converted the earlier EER metric to CSPF and thus were not marked as an improvement. There have been no revisions since. The ASEAN Regional Roadmap for Room Air Conditioners sets MEPS levels at 6.1 CSPF (aligned with the U4E Model Regulations).

We were only able to find historic data of the efficiency of Indonesia's AC for 2021.[r] The data we found 2023[114] used a mix of efficiency metrics EER and CSPF. We converted CSPF to EER for comparability to 2021 using the following formula: CSPF = EER x 1.062 x 0.2930711.

Finally, we used the same approach as in IEA-4E PEET analysis of calculating the average for representative capacities.

REFRIGERATOR-FREEZERS

Indonesia adopted new MEPS for residential refrigerators in September 2021, with an effective date of 2022. The MEPS requires refrigerators to consume no more than (0.85*AV)+270 kWh, when tested at 32 °C, where AV is the adjusted volume in L. Since there were no MEPS in place before the Call to Action, and no revisions since, it is not possible to track progress.

To evaluate progress on efficiency of the typical product in the market, we used the same approach as in IEA-4E PEET analysis of calculating the average for representative capacities, except we used custom capacities as there were very few models at the 150, 300, 450, and 600 L volumes.

We first calculated an average of the baseline unit energy consumptions (UECs) for the single-door (185 L total volume) and double-door (215 L total volume) representative units, based on manufacturer-provided test data from 2019.[115] The result was 325 kWh/year. We compared it to an average of performance for the same units (single-door 185 L +/- 5% total volume and double-door 215 L +/- 105 total volume) listed in the product database as of 2022,[116] which was 360 kWh/year. And again for 2023, which was 351 kWh/year.[117]

[r] EBTKE Registry from 2021

Japan

Japan has Top Runner standards, which are targets for the market average, not the minimum. These are not comparable to MEPS and have a very different function. They have therefore not been included in the comparisons in the body of the paper, but are summarized here for reference.

GENERAL SERVICE LAMPS

Japan has a technology neutral indoor lighting Top Runner requirement of 50 lm/W. As of 2022, there has been no updated policy since.[s]

There was no present or historical data available on the efficiency of Japan's indoor lighting market.

ELECTRIC MOTORS

Japan has Top Runner requirement of IE3 for the electric motors systems. As of 2022, there have been no updated policies.[118]

There was no present or historical data available on the efficiency of Japan's electric motors systems.

SPLIT AIR CONDITIONERS

Japan's Top Runner program has two tiers of requirements: 2010–2026, and 2027 onward (for some classes of ACs, the requirements are delayed by two years such that the first tier started in 2012 and the second will start in 2029).[119] To identify the most common AC type, we reviewed the analysis behind these requirements, which found that the plurality of shipments in 2004 (39.8%) fell within the 2.2 kW class.[120]

TABLE 18: DISTRIBUTION OF SPLIT AIR CONDITIONER SHIPMENTS BY CAPACITY.[121]

APPLICABLE ROOM SIZE IN TERMS OF THE NUMBER OF TATAMI MAPS	COOLING CAPACITY (KW)	TOTAL (NUMBER OF UNITS)
Less than 6	**Less than 2.2**	**70,691 (1.1%)**
6	**2.2**	**2,675,862 (39.8%)**
8	**2.5**	**1,071,935 (15.9%)**
10	**2.8**	**1,489,616 (22.2%)**
11	**3.2**	**7,907 (0.1%)**
12	**3.6**	**280,523 (4.2%)**
14	**4.0**	**670,664 (10.0%)**
Over 14	**Over 4.0**	**455,874 (6.8%)**
TOTAL		6,723,072 (100.0%)

Source: Japan Refrigeration and Air Conditionining Industry Association

(Unit Number of units: 2004 freezing year)

[s] "Target Fiscal Year FY2020 and each subsequent fiscal year."

Looking further, the majority of the models in the 2.2 kW cooling capacity class were of the "free-dimension" type, which describes ACs intended for modern construction (not constrained by the dimensions of traditional Japanese wooden construction).

TABLE 19: DISTRIBUTION OF SPLIT AIR CONDITIONER MODELS AT EACH SIZE BY DIMENSION.[122]

CAPACITY (KW)	2.2	2.5	2.8	3.6	4.0
Dimension-defined	**14**	**11**	**12**	**7**	**8**
Free-dimension	**22**	**20**	**22**	**13**	**14**

The categorization of ACs changed between 2010 and 2026, such that these same ACs fell into the following categories:

- 2010: Category B (up to 3.2 kW, free-dimension type)
- 2026: Category I (non-ducted wall-hung type, except multi-type controlling operation of indoor units individually), up to 2.8 kW, in non-cold regions (the more populated part of Japan)

However, both categories have an annual performance factor (APF) requirement of 6.6 Wh/Wh. In other words, no increase in stringency is anticipated for these popular types of ACs, though the MEPS will become more stringent for some higher-capacity types.

To evaluate progress on efficiency of the typical product in the market, we started with the average APF of models based on "1300 models (all heat pumps, registered from January 2018 to July 2019", reported as 5.86 Wh/Wh.[123] We compared this to models in the current product database.[124] The database contained models posted over 2017–2023, as indicated in the "本サイト掲載" column (machine translated to "Posting date on this site"); however, we did not filter the models using this date, as there was also an "更新" column (machine translated to "Updated date"), which had dates only in 2022–2023. Looking at the "Posting date on this site" column also showed that there were much fewer models from earlier years, suggesting that while many older models had been removed, some stayed on the list (and presumably on the market) as indicated by the "Updated date". The average APF of these models was 5.79 Wh/Wh, slightly lower than in 2019.

REFRIGERATOR-FREEZERS

There have been no updates to Japan's Top Runner requirements for refrigerator-freezers since 2021.

To evaluate progress on efficiency of the typical product in the market, we compared the average annual consumption (kWh/year) of models registered in Japan's product database over multiple years.[125] Unlike the AC database (see above), the refrigerator database has data over the years 2013–2023, with approximately 100 models with a posting date between 2016 and 2020, and over 200 models with a posting date between 2021 and 2022. This wider distribution of model years makes it more likely that past models have remained on the list and makes it possible to estimate the average efficiency in past years.

To estimate the energy consumption in 2021 and 2022, we averaged only models posted in those years and the previous two years. To estimate the energy consumption today, we reviewed models that were updated in 2023 or the prior two years. We chose "updated" rather than "posted" for the present-day because an update would indicate that models are still on

the market even if they were originally posted in an earlier year. Using this method we found the average energy consumption values in Table 20.

TABLE 20: AVERAGE REFRIGERATOR-FREEZER UNIT ENERGY CONSUMPTION IN JAPAN.

YEAR	INCLUDES MODELS WITH THE FOLLOWING DATES	AVERAGE UNIT ENERGY CONSUMPTION (KWH/YR)
2021	**Posted 1/1/2019-12/31/2021**	**283**
2022	**Posted 1/1/2020-12/31/2022**	**285**
2023	**Updated 1/1/2021-12/31-2023**	**275**

Nigeria

GENERAL SERVICE LAMPS

There are no technology neutral MEPS in place for Nigeria's lighting products, therefore we were unable to analyze progress. However, draft technology neutral MEPS were approved by the relevant Technical Committee on 19 May 2023. These are awaiting final approval from the Ministry and implementation.

To evaluate progress on efficiency of the typical product in the market, we analyzed the average luminous efficacy (lm/W) of lamps on the market tested in 2020 and 2021 by the Standards Organization of Nigeria (SOM). We filtered the lamps for descriptors that contained "BULB" to eliminate directional and other special-purpose lighting. Using this method, we found that the average efficiency of bulbs in 2020 was 86 lm/W (117 models), and in 2021 was 88 lm/W (89 models), showing a slight increase in efficiency.[t]

ELECTRIC MOTORS

We were unable to find any MEPS for electric motors in Nigeria.

There was no current or historic data on the efficiency of Nigeria's electric motors market.

SPLIT AIR CONDITIONERS

In 2017, Nigeria implemented a MEPS of 2.8 EER for their residential ACs.[u]

To evaluate progress on efficiency of the typical product in the market, we analyzed the distribution of AC EERs found through CLASP's and IGSD's AC dumping study, collected in 2020.[126] The study published the share of models within each EER class; we ascribed the EER at the middle of the labeling class to all units within the labeling class (e.g., for the 3.5–4.0 EER class we assumed an EER of 3.75 W/W). The resultant weighted average EER was 2.90 W/W.

We compared this result to the average EER of 297 models revealed through web scraping of model data from the Jumia e-commerce site for Nigeria 28 June 2019—30 June 2022.[127] The result was unchanged at 2.90 W/W.

REFRIGERATOR-FREEZERS

A MEPS for refrigerators was first adopted in 2017,[128] and was implemented the same year.

There was no present or historic data available on the efficiency of Nigeria's residential refrigerators market.

[t] Based on CLASP Data.
[u] Text message from Engineer Achema Alewu, Standards Organization of Nigeria to Colin Taylor, CLASP, 13 November 2023.

Panama

GENERAL SERVICE LAMPS

There are no MEPS or efficiency data available.

ELECTRIC MOTORS

There are no MEPS or efficiency data available.

SPLIT AIR CONDITIONERS

There are no MEPS or efficiency data available.

REFRIGERATOR-FREEZERS

As of 2021, Panama has a MEPS of 659 kWh/year for their residential refrigerators. There has been no updated policy since.[129]

There is no historic or present data available on the efficiency of Panama's residential refrigerator market.

South Africa

GENERAL SERVICE LAMPS

In 2021, South Africa's lighting MEPS were set to 14 lm/W (a standard set in 2014). This level is set to increase to 90 lm/W in 2024, and then up to 124 lm/W by 2026.[130]

There is no historic or present data available on the efficiency of South Africa's indoor lighting market that includes all types of lighting products.

ELECTRIC MOTORS

South Africa has no motor MEPS, but there is a proposal to adopt MEPS at IE3.[131]

There is no historic or present data available on the efficiency of South Africa's industrial electric motor systems market.

SPLIT AIR CONDITIONERS

In 2021, South Africa has a residential air conditioner MEPS set at 3 EER (W/W) in 2015.[132] There is a proposal to increase the stringency of the MEPS to 3.2 EER (W/W).[133]

There is no historic or present data available on the efficiency of South Africa's residential air conditioner market.

REFRIGERATOR-FREEZERS

As of 2021, South Africa has a refrigerator MEPS of 598 kWh/year. There has been no updated policy since.[134]

There is no historic or present data available on the efficiency of South Africa's residential refrigerator market.

South Korea

GENERAL SERVICE LAMPS

We were unable to collect MEPS data in Korea.

We were unable evaluate progress on efficiency of the typical product in the market, as the PEET analysis only evaluated LEDs,[135] and not CFLs or incandescents, which are still included in the product database.[136]

ELECTRIC MOTORS

As of 2021, South Korea has a MEPS of IE3 and there has been no updated policy since.[137]

To evaluate progress on efficiency of the typical product in the market, we compared the simple average of energy efficiency percentage at full load across the four size categories in the PEET analysis: 2.2 kW +/- 5%, 7.5 kW +/- 5%, 20 kW +/- 5%, and 75 kW +/- 5%. However, there are no 20 kW motors in the database or in IEC standard 60034-30-1, so we believe that to be an error and changed it to 22 kW, which continues the pattern for the other size categories. The average efficiency in 2019 was 92%,[138] while the same analysis, recreated using models listed in the 2023 South Korean database, revealed a slightly higher average efficiency at full load of 93%.[139]

SPLIT AIR CONDITIONERS

As of 2021, South Korea has a MEPS of 4.4 SEER.[140] There has been no updated policy since.

To evaluate efficiency in 2019, PEET calculated simple average of energy efficiency ratio (CSPF) across four size categories: 2 kW +/- 5%, 3.5 kW +/- 5%, 5 kW +/- 5%, and 7 kW +/- 5%. The average in 2019 was 5.83 CSPF.[141] We were unable to recreate this analysis using 2023 data.

REFRIGERATOR-FREEZERS

There is no MEPS or efficiency data available.

United Kingdom

GENERAL SERVICE LAMPS

Progress in the UK follows that in the EU, however, there is currently an ambitious MEPS proposal for lighting products with one set of requirements in late 2023 and 140 lm/W by September 2027.[142]

For the average efficiency on the market, we analyzed retailer data provided by GfK and found that sales-weighted efficiency on the market was as shown in the following table; however, there were no data available following the signing of the Call to Action.

TABLE 21: SALES-WEIGHTED AVERAGE EFFICIENCY OF LAMPS ON THE UK MARKET.

YEAR	SALES-WEIGHTED AVERAGE EFFICIENCY (LM/W)
2018	**91.0**
2019	**93.9**
2020	**96.6**
2021	**97.4**

ELECTRIC MOTORS

Same as that in the EU.

SPLIT AIR CONDITIONERS

Same as that in the EU.

REFRIGERATOR-FREEZERS

Same as that in the EU.

United States

GENERAL SERVICE LAMPS

In 2021, the US had a MEPS of 18 lm/W for their indoor lighting products. As of 2022, this standard went up to 45 lm/W and there is now a proposal in place to raise this standard to 124 lm/W in 2029.[144]

ELECTRIC MOTORS

The US has a MEPS of IE3 for their electric motors;[145] however, a new standard harmonized with that in the EU was adopted on 1 June 2023, and will take effect on 1 June 2027.[146]

SPLIT AIR CONDITIONERS

In 2021, the AC MEPS was set at 13 US SEER, but as of 2023 the new standard in place is at 14 US SEER.[147]

To evaluate progress on efficiency of the typical product in the market, we calculated the average efficiency of products projected for 2021 using the US Department of Energy's (DOE's) 2016 Final Technical Support Document (TSD):[148]

1. We first calculated the average efficiency of each product type (blower-coil, coil-only, and heat pump) simply averaged across regions (North, Hot Dry (Southwest), and Hot Humid (Southeast) using efficiency distribution tables in the TSD:

TABLE 22: REGIONAL EFFICIENCY DISTRIBUTIONS IN THE NO-NEW-STANDARDS CASE FOR SPLIT-SYSTEM COIL-ONLY CENTRAL AIR CONDITIONERS[149]

SEER	NORTH	HOT DRY	HOT HUMID
13	43%	0%	0%
13.5	43%	0%	0%
14	3%	48%	48%
14.5	3%	48%	48%
15	1%	1%	1%
15.5	1%	1%	1%
16	3%	2%	1%
16.5	3%	2%	1%
17	0%	0%	0%

2. We then converted the seasonal energy efficiency rating (SEER) to the recently adopted SEER2 by linearly interpolating from the change of DOE standards (i.e., the original 14 SEER requirement effective January 1, 2023 was revised to 13.4 SEER2, while the 15 SEER requirement was revised to 14.3 SEER2). The resultant crosswalk was similar to ones developed and published by others, shown in Table 23.

TABLE 23: CROSSWALK FOR CONVERTING BETWEEN SEER AND SEER2.[150]

SEER2 CROSSWALK	SEER
12.5	13
12.95	13.5
13.4	14
13.85	14.5
14.3	15
14.75	15.5
15.2	16
15.65	16.5
16.1	17

3. Finally, we calculated a simple average across the three product classes, resulting in a SEER2 of 14.3.

We compared this result to the SEER2 for products listed in the Compliance Certification Management System (CCMS),[151] first filtering out models that could not be sold in each of the three regions based on the 2023 standards,[152] resulting in the following table, for which we calculated a simple average across the region and then the product type, resulting in an average SEER2 of 15.2, across all product classes and regions.

TABLE 24: AVERAGE AC EFFICIENCY ACROSS US REGIONS.

SEER2 (BTU/WH)	NORTH	HOT DRY	HOT HUMID
Coil-Only	15.2	14.5	14.5
Blower-Coil	15.2	15.4	15.4
Heat Pump	15.6	15.6	15.6

REFRIGERATOR-FREEZERS

To evaluate progress on MEPS, we reviewed the ongoing Department of Energy rulemaking. The last standard took effect in 2014, though a revised one was proposed on 27 February 2023.[153]

To evaluate progress on efficiency of the typical product in the market, we calculated the rated energy consumption for each standard-size refrigerator-freezer product class at each representative adjusted volume (AV) and efficiency level (EL), as reported in the 2021 US Department of Energy (DOE) Refrigerators-freezers Preliminary Technical Support Document (TSD).[154] While the TSD is intended to project efficiency in 2027 (when a potential revised standard would take effect), it uses data from 2021 and assumes no change between 2021 and 2027. The process required three steps:

1. We first took the base-case efficiency distribution by each efficiency level (EL) analyzed by DOE:

TABLE 25: US EFFICIENCY DISTRIBUTION FOR REFRIGERATORS, REFRIGERATOR-FREEZERS, AND FREEZERS.[155]

PRODUCT CLASS	TOTAL ADJUSTED VOLUME (CU.FT.)	2027 MARKET SHARE (%)					
		EL 0	EL 1	EL 2	EL 3	EL 4	TOTAL*
3	11.9	67.1	32.9	0	0	0	100
	21	66.1	33.7	0.2	0	0	100
5	12.9	80.3	13.9	5.7	0	0	100
	23	80.2	19.8	0	0	0	100
5A	39.9	29.8	68.4	1.1	0.2	0.5	100
7	31.5	94.2	1.7	1.2	2.4	0.5	100

2. Then we calculated the rated energy consumption of each EL using the percentage energy reduction from baseline (current minimum standard).

TABLE 26: EFFICIENCY LEVELS (ELS) FOR ANALYZED PRODUCTS (% ENERGY USE LESS THAN BASELINE).[156]

PRODUCT CLASS	3	3	5	5	5A	7
Representative Adjusted Volume (AV, ft^3)	11.9	21	12.9	23	39.9	31.5
EL0 (Baseline)	0%	0%	0%	0%	0%	0%
EL 1*	10%	10%	13%	10%	9%	10%
EL 2	14%	18%	21%	26%	15%	15%
EL 3	19%	21%	38%	30%	20%	19%
EL 4 - Max Tech	23%	25%	41%	35%	22%	21%

TABLE 27: ANNUAL ENERGY CONSUMPTION IN KWH /YEAR AT EACH EFFICIENCY LEVEL (EL).

PRODUCT CLASS	3	3	5	5	5A	7
Representative Adjusted Volume (AV, ft^3)	11.9	21	12.9	23	39.9	31.5
EL0 (Baseline)	330	403	431	521	844	702
EL 1*	297	363	375	468	768	632
EL 2	284	331	341	385	718	597
EL 3	267	319	267	364	676	568
EL 4 - Max Tech	254	302	254	338	659	554

3. Finally, we calculated a simple average across the product classes and representative unit volumes, resulting in 520 kWh/yr.

We compared this result to the average annual energy consumption averaged across those same product classes and representative volumes +/- 5% for products listed on the Compliance Certification Management System (CCMS).[157] The result was 505 kWh/yr.

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