Baseline Evaluation and Policy Implications for Air Conditioners in Indonesia

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Abstract
Rapid adoption of air conditioners (ACs) in Indonesia is driving an unprecedented increase in electricity demand. Meeting this added demand will require an estimated investment of $US40 billion in electricity generation. Ambitious energy-efficiency policies are urgently needed to address this growing challenge.

In 2015, the Indonesian government established the first standards and labeling program (S&L) for ACs. Lawrence Berkeley National Laboratory (LBNL), through its activities in support of the Super-efficient Equipment and Appliance Deployment initiative, identified lack of market data as a major impediment to development of a rational, effective policy to address AC energy demand in the country. This paper aims to establish a market efficiency baseline in order to (1) inform program design of the next AC S&L program in Indonesia and (2) allow for tracking the impact of that program in relation to a robust baseline.

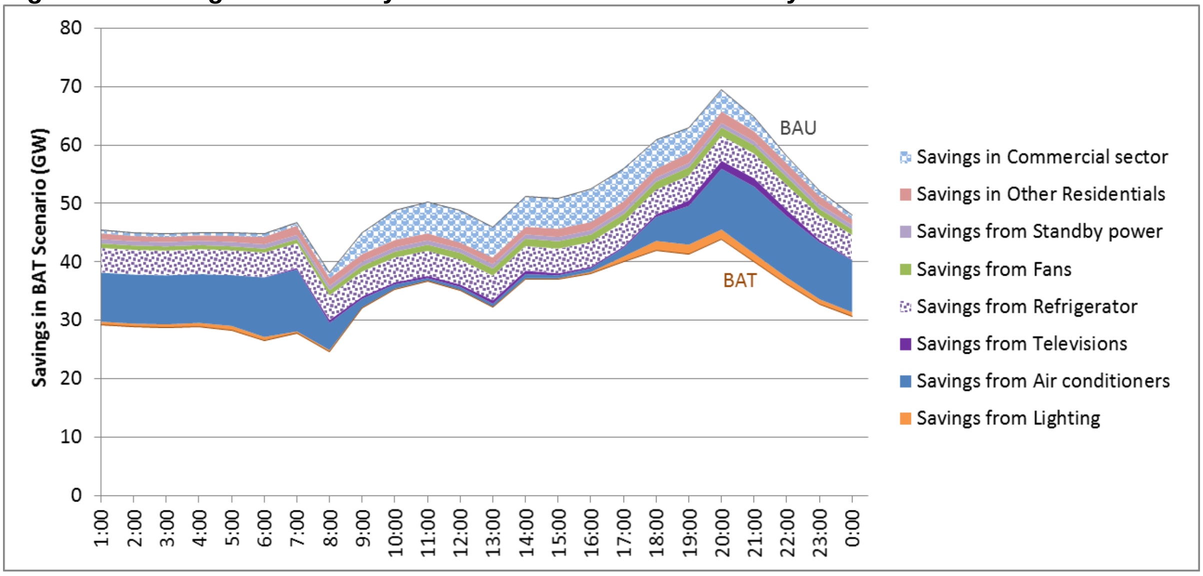
LBNL has collected data by deploying the International Database of Efficient Appliances (IDEA) in Indonesia. On-the-ground contributors collected data using smart-phone technology, and data were also obtained from manufacturer websites and government registration data associated with the newly implemented S&L program. The resulting database gives a detailed, robust picture of Indonesia's AC market, including product characteristics, efficiency ratings, and retail prices.

This paper presents AC efficiency and price distributions according to Indonesian efficiency label (star) rating. We include characteristics of products from local manufacturing and imports to address Indonesian government concerns regarding local industry. Based on these data, LBNL estimates the cost of conserved energy of different efficiency targets and formulate a set of policy recommendations to help increase the energy savings from Indonesia's S&L program. The recommendations include revising the S&L program for ACs, increasing stakeholder engagement, identifying regulatory barriers/reforms need and institutionalizing the type of analysis presented in this paper for future S&L revisions.

Background
Indonesia is the largest energy consumer in Southeast Asia, accounting for more than 36% of the region's energy demand. With a strong economic growth forecast and electricity consumption expected to increase by 8%-9% per year, the country has significant energy-efficiency potential in every economic sector.

Previous studies from Lawrence Berkeley National Laboratory (LBNL) have evaluated the potential for energy efficiency from lighting, appliances, and equipment to reduce future energy demand and associated carbon dioxide (CO_2) emissions and save consumers billions of dollars in electricity expenditures in Indonesia [2] [3]. Other research has forecasted future installed power generation capacity using a bottom-up approach to show the potential impact of energy-efficient lighting, appliances, and equipment on Indonesia's peak load [1] [4]. These studies show that the rapid adoption of air conditioners (ACs) in Indonesia is driving an unprecedented increase in electricity and installed capacity demand. Using recent AC sales data and macro-economic modeling, we estimate that 75 million AC units will be added to the stock between 2015 and 2030 [5]. Meeting this added cooling demand will require an estimated 20 gigawatts (GW) of additional capacity, representing an investment of $40 billion in electricity generation [6]. The studies also show that increasing the energy-efficiency of AC technology has the potential to save significant energy. Ambitious energy-efficiency policies are urgently needed to transform the market toward more efficient ACs and address the growing energy challenge posed by the growth in AC use.

Figure 1 – Savings Potential by End Use from Peak-Load Analysis for Indonesia



Source: LBNL peak load analysis [1]
Note: Peak-load analysis shows that 50% of energy-efficiency potential from appliances in 2030 is attributable to ACs [3].

LBNL, through its technical assistance activities in support of the Super-efficient Equipment and Appliance Deployment (SEAD) identified that Indonesia's S&L program for ACs could be more stringent to achieve energy-efficiency savings, which otherwise will remain untapped. Our collaborators at the Indonesian Ministry of Energy and Mineral Resources (MEMR) had identified lack of market data as a major impediment to establishing more ambitious AC efficiency programs.

This paper aims to establish a market efficiency baseline in order to (1) inform program design of the next AC S&L program in Indonesia and (2) allow for tracking the impact of that program in relation to a robust baseline. Finally, we offer recommendations based on evidence from the market and our discussions with MEMR and stakeholders in Indonesia.

Indonesia Standards and Labeling Program Status and Prospects

MEMR is responsible for implementing energy-efficiency and conservation programs [7]. Because of the potential for improving appliance energy efficiency, Indonesia has been developing minimum energy performance standards (MEPS) and energy-efficiency labels. In 2010, MEMR established the Directorate General (DG) of New Renewable Energy and Energy Conservation (EBTKE). Under this DG, the Directorate of Energy Conservation (DEK) develops and implements energy conservation programs. DEK works in all sectors—industrial, residential, commercial, transportation—and communicates with the relevant ministries in these sectors.

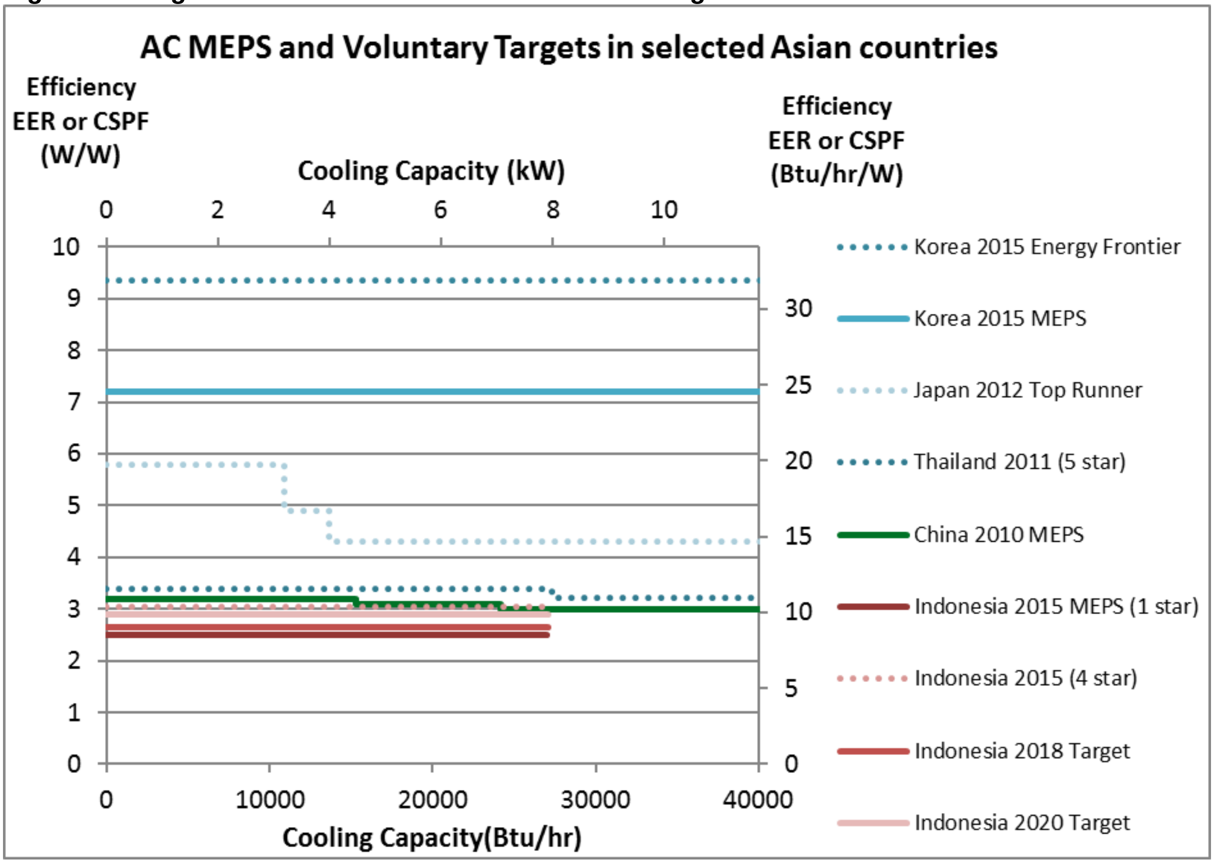
The first draft regulations were developed with the support of the Barrier-Removal for Efficiency Standards and Labels (BRESL) program and covered the following products: compact fluorescent lamps (CFLs), ACs, refrigerators, fans, rice cookers, and motors. With the development of draft regulations for these seven products, the BRESL program ended in 2013 [8]. More recently, MEMR is considering adding light-emitting diode (LED) lamps, washing machines, electric irons, and televisions to the S&L program.

The first star label was made mandatory for CFLs in 2014 and took effect in June 2015 [9]. The first MEPS regulation for ACs was issued in 2015 and took effect in August 2016 [10]. The AC regulation defines a labeling scheme from one to four stars, with a mandated minimum efficiency level of 2.5 energy-efficiency rating (EER) for one star and 3.05 EER for four stars.

The Association of Southeast Asian Nations (ASEAN) Standards Harmonization Initiative for Energy Efficiency (SHINE) program has supported Indonesia's AC MEPS. ASEAN SHINE has worked with all ASEAN economies to harmonize standards across the region. In Indonesia, the SHINE program work resulted in a regional target of 2.9 EER [11] and adoption of a national roadmap to reach this level by 2020, with an intermediate target level at 2.65 EER in 2018 [12].

Figure 2 compares the Indonesia MEPS, high-efficiency label (4 star), and planned roadmap in comparison with relevant MEPS and voluntary targets in Asia.

Figure 2 – Regional Benchmark for Air-Conditioner Regulations



Source: Authors' own elaboration based on [10][11][13]

As illustrated in Figure 2, in comparison with other countries in the region, Indonesia's MEPS and labeling program are not very ambitious. As a result, a large portion of energy-efficiency savings potential remains untapped. These untapped opportunities negatively affect the following stakeholders in the following ways:

- Consumers – Indonesian consumers and businesses who buy low-efficiency units waste money in electricity bills over the appliance's lifetime. In view of the long hours of AC use and market electricity tariffs,[1] we estimate that the average consumer can save $US150 over the lifetime of an AC by switching to more efficient technology, amounting to $US12 billion savings by 2030 in consumer expenditures at the national level.

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[1] As of March 2015, the household customer class with connections of 1,300 volts ampere and above, the business class with medium and large power connections, and most government classes have already reached or exceeded the market price that the State Electricity Company (PLN). targeted, around 1,350 Indonesian Rupiahs ($US 0.10) per kilowatt-hour.

- Local manufacturers – Local manufacturers are missing business opportunities to increase cash flow by selling more energy-efficient units. Selling “economic” ACs that would save the consumer money would increase local brand popularity and competitiveness against imported units. In the medium term, Indonesia’s local manufacturers could also compete on the export market.
- Utility and other electricity supply providers – Each AC bought for the first time adds approximately 350 Watts (W) of electricity demand to the grid (based on the AC usage load shape and peak-load analysis in [4]). Using an average cost of $US2/W, this is equivalent to $US700 per new AC, much more than the price of the AC itself. Even for consumers in the high-tariff category, it will take many years for electricity service providers to recover their initial investment to meet this added demand. The role of public utilities is to provide the electricity necessary to meet customer demand, but it is important for utilities to consider the business opportunity of energy efficiency. Further insights on cost of conserved energy (CCE) for high-efficiency versus standard units are presented in Table 2 below.
- Nation – Efficient electricity use is key to achieving Indonesia’s CO_2 mitigation goal. We estimate that 57 million tons (Mt) CO_2 could be saved each year from more efficient ACs alone, amounting to 390Mt CO_2 between now and 2030.

These energy-efficiency benefit estimates are based on our international experience and ballpark numbers generated to make the case for energy-efficiency policies that address AC demand in Indonesia. To develop effective, rational AC regulations, detailed data are needed to characterize AC market players, technology, price, and efficiency. The following sections describe our work to support MEMR in increasing the stringency of Indonesia’s AC S&L program.

Data Sourcing

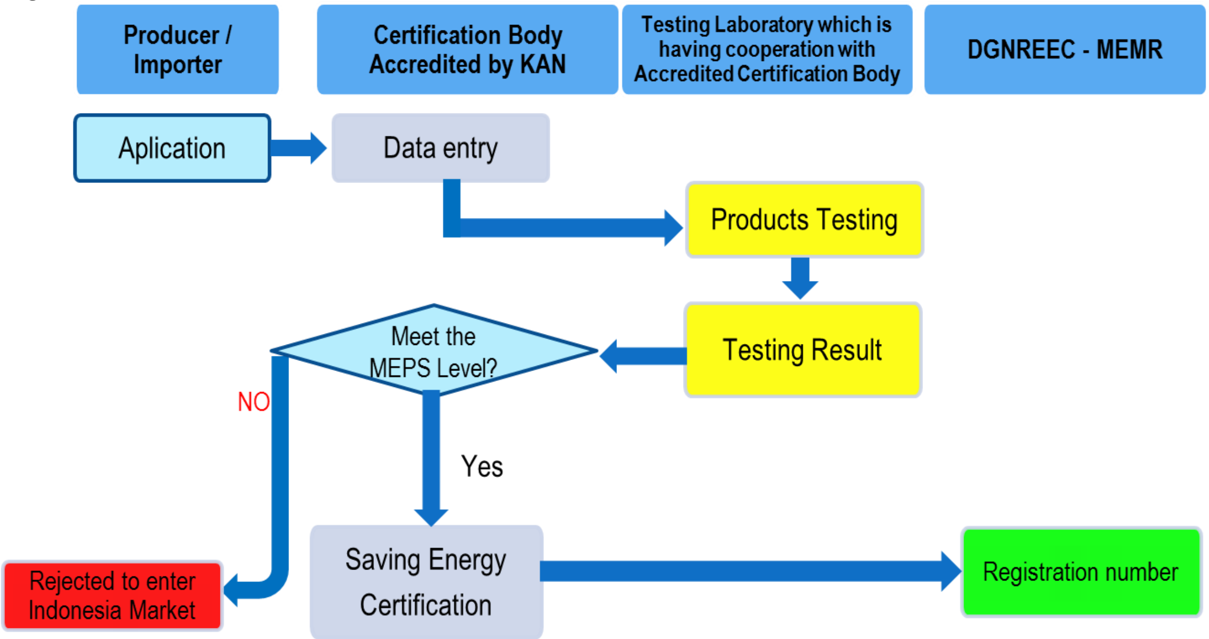
An essential first step in developing effective energy-efficiency policy is an analysis to determine the features of typical products on the target market and the range of efficiency levels from products on the market. This market analysis forms a baseline against which to evaluate the potential impact of new policy actions and enables us to determine the degree to which some products currently available on the market exceed the baseline.

Our market analysis relies on three main data sources, described in the subsections below.

Certification Database

Since MEMR began implementing the AC S&L program, the certification database has become an available source for product information. MEMR provided this robust data source as part of the SEAD collaboration. MEMR generates registration numbers for certified products that meet the MEPS. A certification body accredited by the national committee of accreditation (KAN) certifies products after they are tested by an accredited test laboratory. MEMR collects the data from the certification body and test laboratories. The data include applicant (importer/distributor, manufacturer), product brand, model number, product characteristics and features (cooling capacity, inverter), EER, and origin (locally produced or imported).

Figure 3 – Certification Process for ACs in Indonesia



Source MEMR

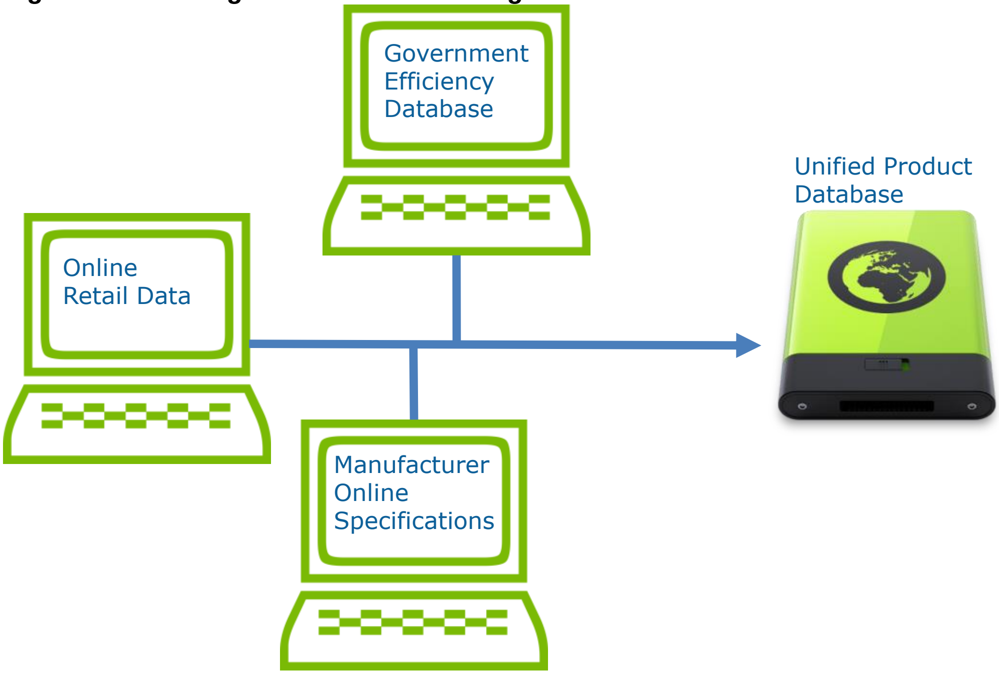
The AC S&L program took effect in August 2016, so the government certification database is still under construction. Nevertheless, at the time of this paper's publication, 330 models had already been tested, certified, and registered in the database. MEMR believes that the database covers most units that are being sold on the market. MEMR started market surveillance activities in 2017 with a check-testing program where sample units have been taken from the market in three locations (so far): Bandung, Yogyakarta and Denpasar. The units will be sent in a laboratory to be tested and verify the information submitted to the certification database. At the time of this paper's publication, test results are not available.

Web Survey: International Database of Efficient Appliances

As discussed earlier, the major barrier to the optimal implementation of Indonesia's S&L program is a lack of market data. This issue is very common and particularly acute in developing countries. To help resolve this data gap and support development and implementation of effective S&L programs around the world, LBNL has developed the International Database of Efficient Appliances (IDEA) [14]. IDEA compiles data from a wide variety of online sources to create a unified repository of information on efficiency, price, and features for a wide range of energy-consuming products on global markets. To our knowledge, IDEA is the first fully functioning implementation of a global data-access framework [15].

In Indonesia, IDEA draws data from a variety of disparate sources, including online retailers, manufacturer websites, and MEMR certification database presented above.. IDEA combines the information from these existing sources of public data, which are currently dispersed across the internet, into a rich data set. Figure 4 illustrates the different components in building a unified product database.

Figure 4 – Building a tool for Data Mining - IDEA Framework



Source: Authors' own elaboration

IDEA has been deployed for Indonesia since October 2015 and has been enhanced with MEMR's certification database since the implementation of the AC program. IDEA is currently collecting data using automated web crawling software to extract data from from two large online stores (Bhinneka and Lazada) and large department stores with e-commerce interfaces (Electronic City and Wahana Superstore). Data are also cross-checked with 10 manufacturer websites before being integrated with the MEMR certification dataset using IDEA software tools for data cleaning and data matching.

The IDEA data set has many valuable applications in energy-efficiency policy development and program implementation support, including market monitoring and impact evaluation. With the capacity for regular, automated data updates from public, online data sources, IDEA enables real-time tracking of market trends, including a market's energy-efficiency progress and price trends for efficient technology (e.g., as in [16]). IDEA also allows comparison of markets between countries to support international benchmarking studies.

Retail Survey: Premise Data Set

A data set was collected to provide a "reality check" for IDEA. In collaboration with Premise, a company that offers real time macroeconomic data collection powered by a global network of contributors, LBNL conducted an initial baseline measurement exercise to collect data on the price and energy-efficiency labeling of air-conditioning units in Indonesia [17]. Between February and April 2016, Premise deployed on-the-ground contributors to capture, through smart-phone applications, hundreds of observations in cities and rural areas across the country. Figure 5 shows examples of Premise AC data documenting model number, brand, cooling capacity, price, efficiency, geographical area of data collection, and number of observations recorded.

Figure 5 – Screenshot of Premise Data Platform

Source: Premise

These data provide an understanding of (1) the product mix of air-conditioning units in “brick and mortar” retail, (2) pricing of ACs relative to specifications and features, and (3) the current level of energy efficiency available on the market from various brands/manufacturers.

Data Sourcing - Summary

Because there is no single source for all market data needed to establish a successful program, a country/program seeking to collect data for this purpose should evaluate the optimal approach based on the technical and financial resources available.

Table 1- Summary of Advantages and Disadvantages of Data Sources

	Advantages	**Disadvantages/Possible Bias**
Government Data: Certification Database	-Certified efficiency -Certified features -Imports vs. domestic production	-Under construction -No indication of popularity -No indication of availability
Web Survey: IDEA	-Automated data collection -Accurate price data -Tracking of price and efficiency trends -Popularity -Availability	-Depends on data quality from E-commerce and government database
Retail Survey: Premise Data Set	-Retail stores carry most popular AC models -Price data -Location data	-Issue with data quality for technical data (can be fixed with pre-defined fields/training) -Study needs to be commissioned

Data Analysis and Results

The following section presents some analysis of the data from IDEA, combined with information from the Premise data set, MEMR's certification database, and the local manufacturer association (GABEL) when possible.

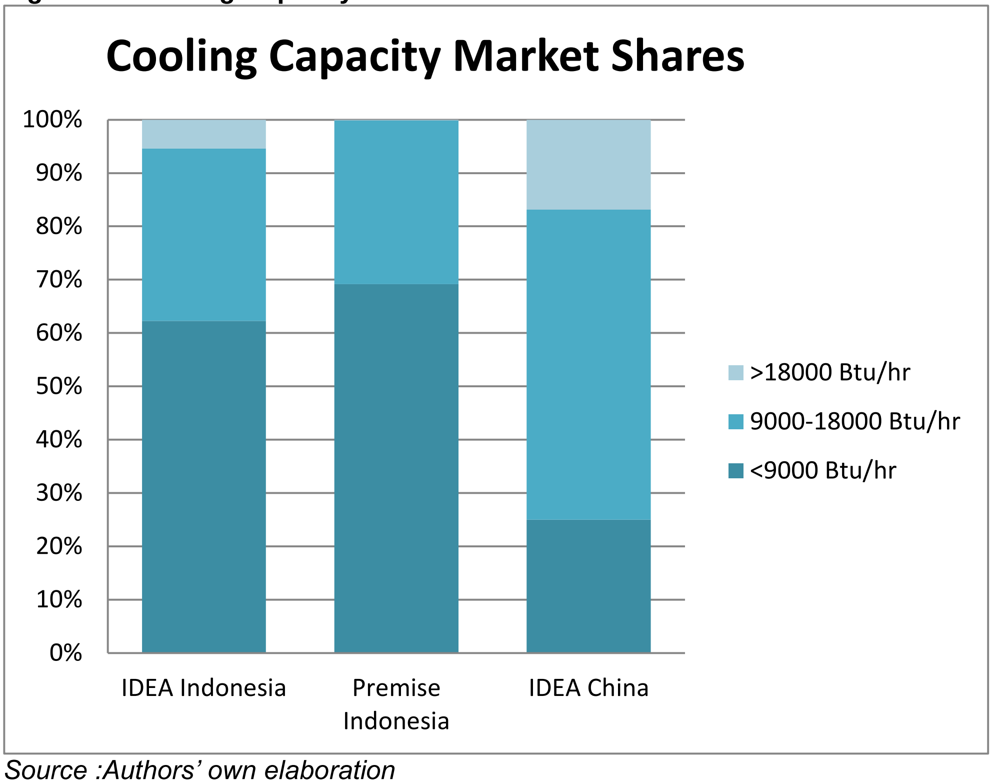
Product Characteristics

Product characteristics, such as cooling capacity and technology type, are important to analyze because they can differ from one country to another depending on availability, affordability, and cultural preferences.

Cooling Capacity

In Indonesia, we find that small-capacity ACs are very popular. The manufacturer association refers to them as "low-wattage" units. They are designed to serve households with a low volt-ampere (VA) connection. We find that units below 1 refrigeration ton (RT), equivalent to 12,000 British thermal units per hour (Btu/hr), account for approximately 80% of the market. The breakdown of ACs on the market by cooling capacity from Indonesia and China [18] shows that the Indonesia market has a high share of very small AC models (Figure 6).

Figure 6 – Cooling Capacity Distribution



Source :Authors' own elaboration

The size of an AC unit affects unit energy consumption (UEC) and thus electricity bill savings. Unit-level cost-benefit analysis and other impacts on consumers should be assessed carefully.

Inverter ACs

An interesting attribute of ACs that greatly impacts energy performance and price is inverter technology. Inverter ACs can run at part load, which increases their efficiency compared to units that do not have inverters.

The share of models with inverter ACs is relatively small, at 17%, compared to traditional fixed-speed ACs in Indonesia, based on the number of models collected by IDEA. Premise data show that 28% of models have inverters whereas the certification database reports that 29% of models have inverters. The manufacturer association, GABEL, estimates the sales market share of inverter ACs at about 7%.

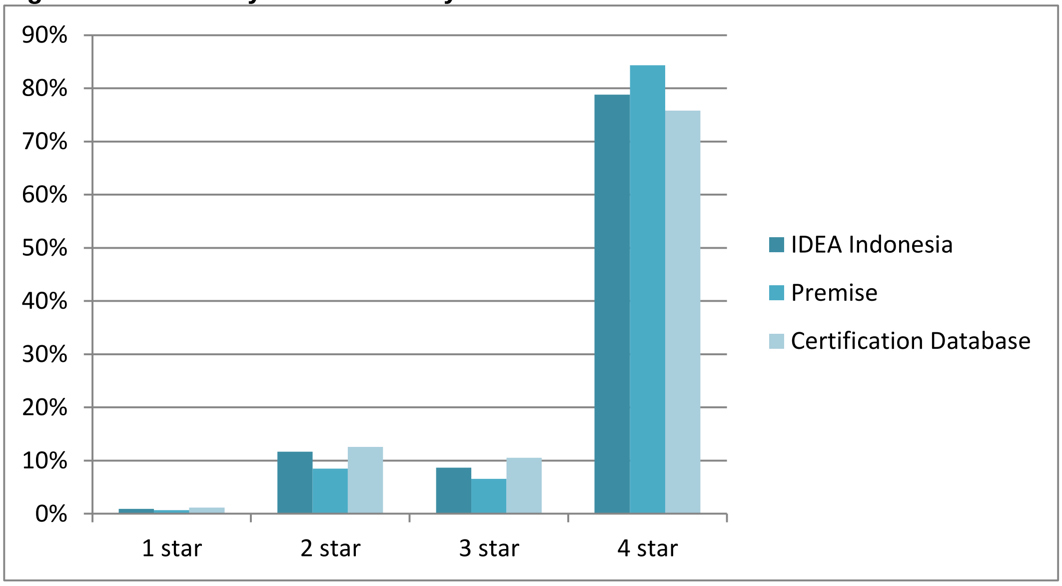
Given the substantial incremental cost of inverters, it is likely that the share of certified models with inverters is larger than the share of units with inverters on the sales market as a whole.

Efficiency Distribution

Efficiency distributions are important for characterizing possible targets of a MEPS program. These distributions also form a basis for scaling star label categories so that consumers can identify the high-efficiency products on the market.

The three data sets show a similar efficiency distribution of models among the four different star levels according to Indonesia's current labeling policy (Figure 7). This provides the data to understand the need for increasing the energy efficiency requirements in 2018 and 2020 S&L policies, with more than 75% of products currently in the 4 star bin.

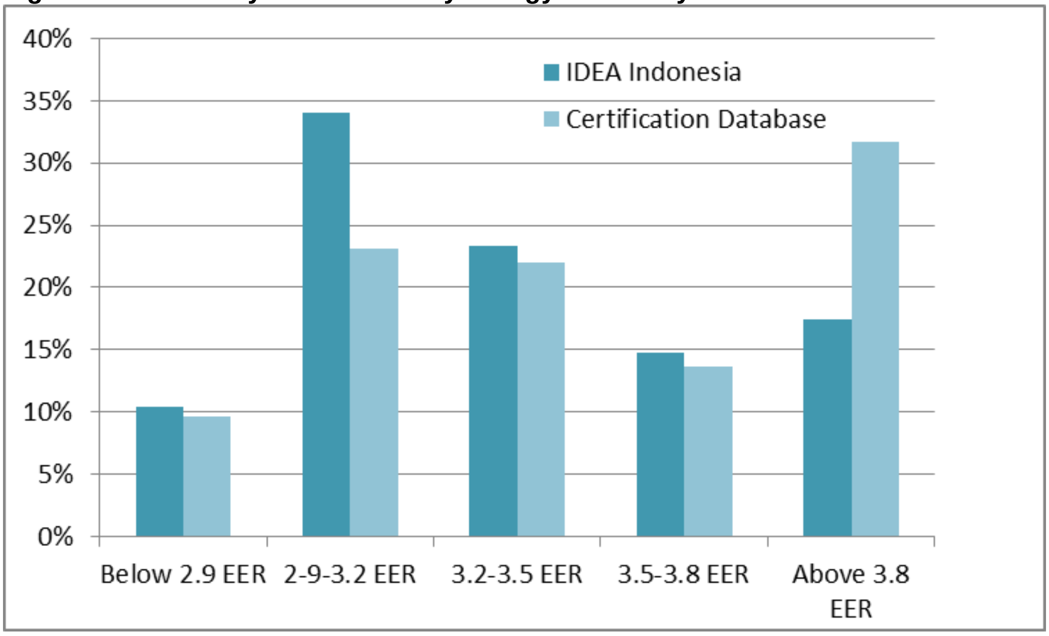
Figure 7 – Efficiency Distribution by Star Label



Source :Authors' own elaboration

To further understand the distribution of currently available AC products, we examined the product data in increments of 0.3 EER (Figure 8). This data shows the efficiency distribution by EER (W/W) and can be used to inform a re-scaling of the 2018 and 2020 S&L policies.

Figure 8 – Efficiency Distribution by Energy-Efficiency Ratio

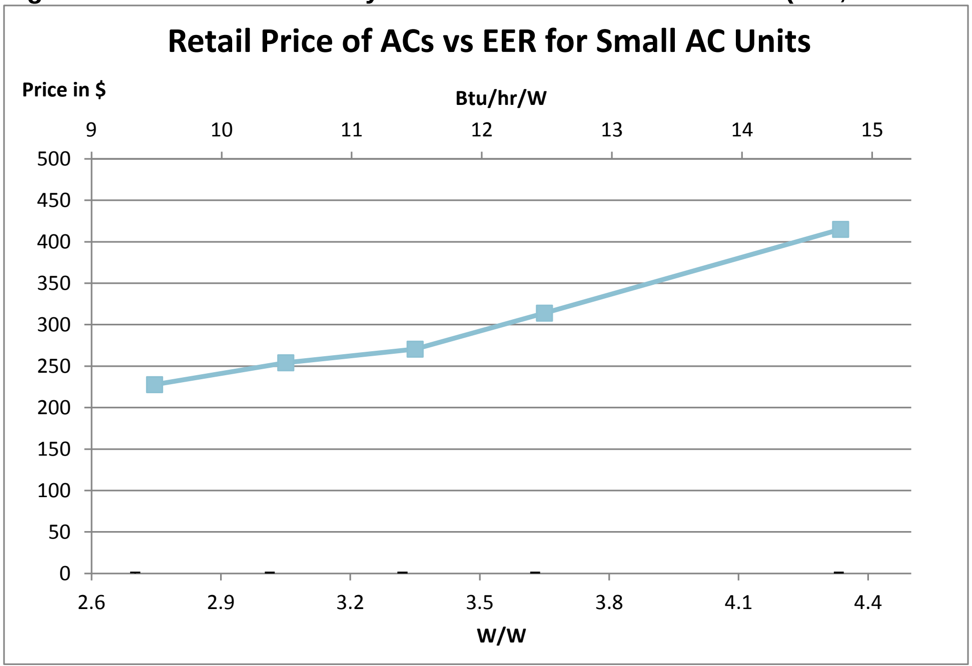


Source :Authors' own elaboration

Price versus Efficiency

A key insight from IDEA is characterization of the relationship between retail product price and efficiency. This relationship is critical for understanding the impact of the program on consumers and for designing a well-founded 2018 and 2020 S&L policies. We calculate average price by efficiency bin for small AC units (<12,000Btu/hr), which account for 80% of the AC units surveyed. We find minimal increase in the retail prices for increasing the efficiency up to 3.3 EER (Figure 9). For AC units with an EER above 3.3, prices tend to rise more rapidly because inverter technology is more prevalent.

Figure 9 – Price vs. Efficiency for Small Air Conditioner Units (<12,000 Btu/hr)



Source :IDEA Indonesia

To evaluate cost effectiveness at the unit level, we calculate the CCE of the different efficiency options. CCE is defined as the incremental equipment retail price divided by annual energy savings. A consumer discount rate is used to annualize the incremental price of high-efficiency equipment. The unit of CCE is cost (in $US) per kilowatt-hour (kWh), which makes CCE directly comparable to electricity prices. CCE is compared to the marginal price of electricity that the user pays (residential or commercial tariff, depending on connection type) or that the utility pays for generation on the margin. If the CCE is lower than the cost of electricity, then the option is cost effective.

Using retail prices is not ideal because these prices may include markups that reflect aspects other than just the cost of higher efficiency (especially at the high end of the market). To estimate prices of efficient units, we usually recommend using an engineering approach that builds on tear-down analysis and component costs. Because retail prices are higher than engineering-based prices, we overestimate the cost of efficiency, which makes our approach conservative. Even under these circumstances, all options are cost effective from different points of view (Table 2).

Table 2 – Cost of Conserved Energy of Various Efficiency Targets

Market Segment	EER	UEC	Price	CCE
	W/W	*kWh*	*$*	*$/kWh*
MS #1 (Below 2.9 EER)	2.75	1651.9	228	
MS #2 (Below 2008 Chinese MEPS)	3.05	1487.2	254	0.036
MS #3 (Incremental)	3.35	1354.1	271	0.032
MS #4 (Incremental)	3.65	1242.8	314	0.047
MS #5 (Above 3.7 EER)	4.34	1046.0	415	0.069

Additional input data: Average size below 1RT: 7560Btu/hr, Discount rate: 12.4%, Hours of use: 5.6hrs/day, AC Lifetime 7 years

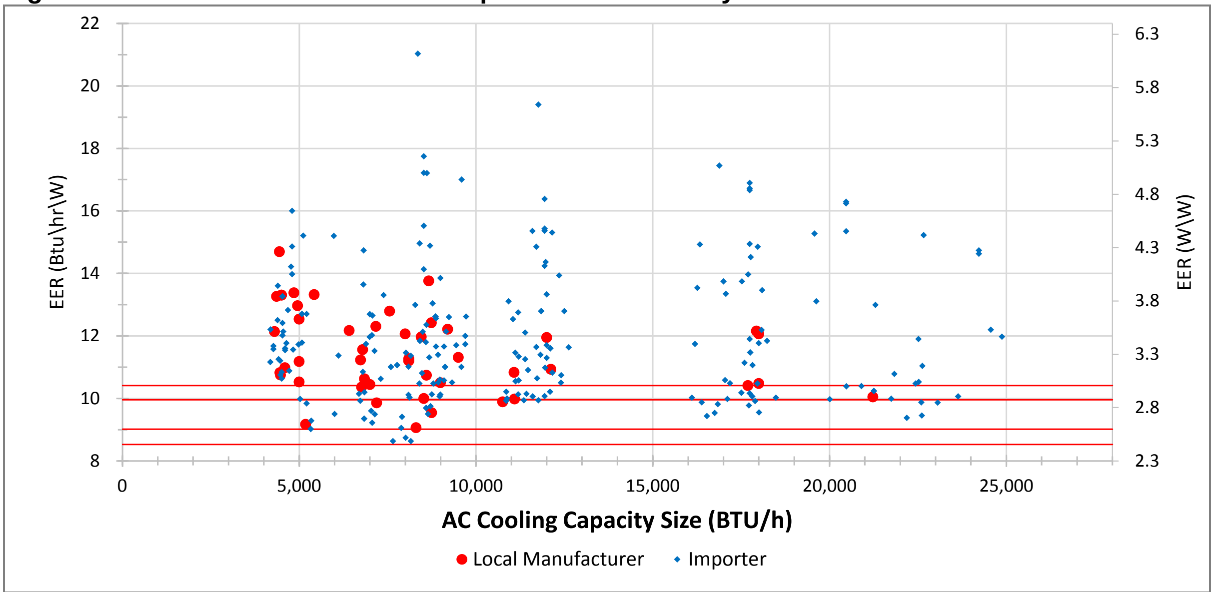
Given that the typical cost of electricity for unsubsidized customers is around 10cts/kWh, all options are cost effective from the consumer point of view. From the utility point of view, the market price of electricity is at least of 10cts/kWh (and much higher at peak demand), so all the options are also very cost-effective from their point of view.

Local Manufacturing

As shown above, all efficiency targets are cost-effective for most stakeholders and potential for the national benefits are large. One of the sticking point in getting more stringent standards in place has been local manufacturer opposition. The following data and analysis offers some insights to support further discussions with local manufacturers and offer possible solutions to enable benefits for consumers, utilities, and society as a whole.

The Premise data set offers insight on what brands are sold in stores, and the certification database offers insights on the products that are registered for import and for local manufacturing. The certification database provides insights into the potential impacts of a MEPS removing star-levels and a rescaling of the label (Figure 10).

Figure 10 – Local Manufacturer vs. Importer AC Efficiency in the Certification Database



Source :[10] and MEMR certification database

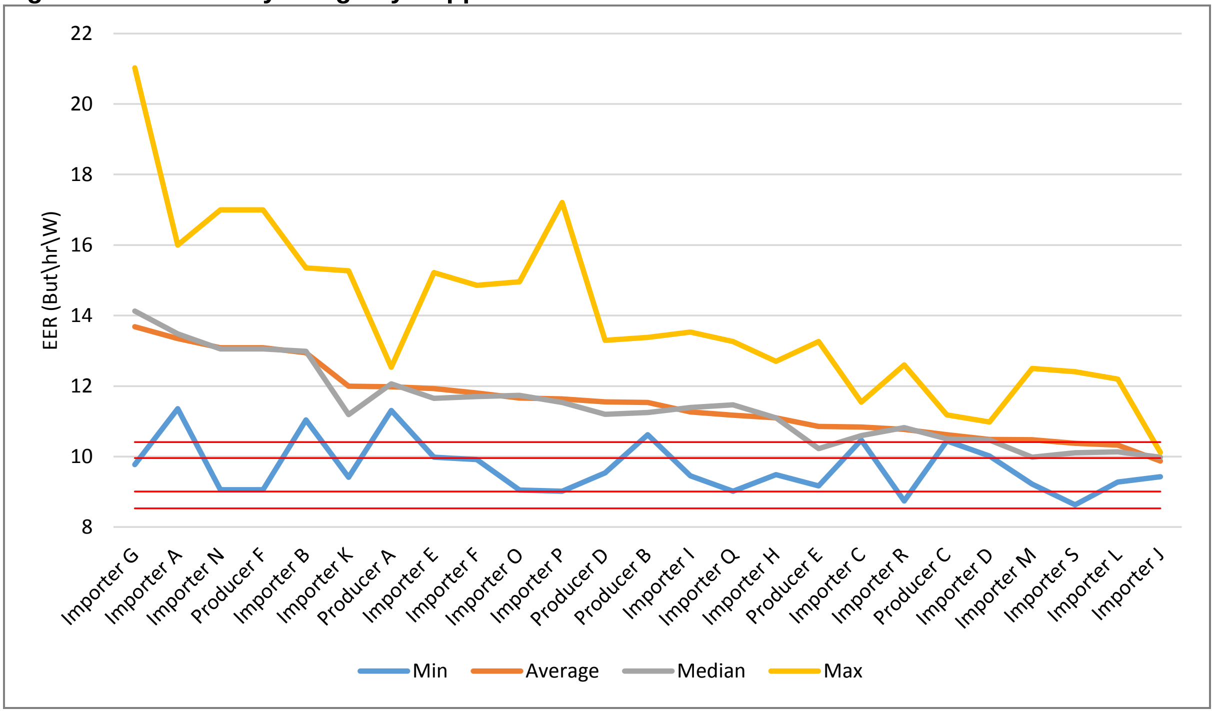
Through these data sets, we find that:

- All 1-star AC models are imported.
- 80% of the locally manufactured and assembled AC models are certified at the 4-star level.
- Nearly 20% of the AC models are locally manufactured or assembled.
- 100% of local manufacturers have at least one 4-star certified AC model.

- The market is dominated by international brands; four brands (Samsung, Sharp, Panasonic, LG) represent 75% of the models are either imported or assembled locally, and include both some of the most efficiency and some of the least efficiency products.
- Three local manufacturers have only assembly factories (i.e. no production lines).

The data also demonstrates there is a range of product efficiencies available from all manufacturers, but that five importers are currently offering the least efficient suite of products (Figure 11). This indicates that there is an opportunity to eliminate low products in the coming years without impacting local manufacturing.

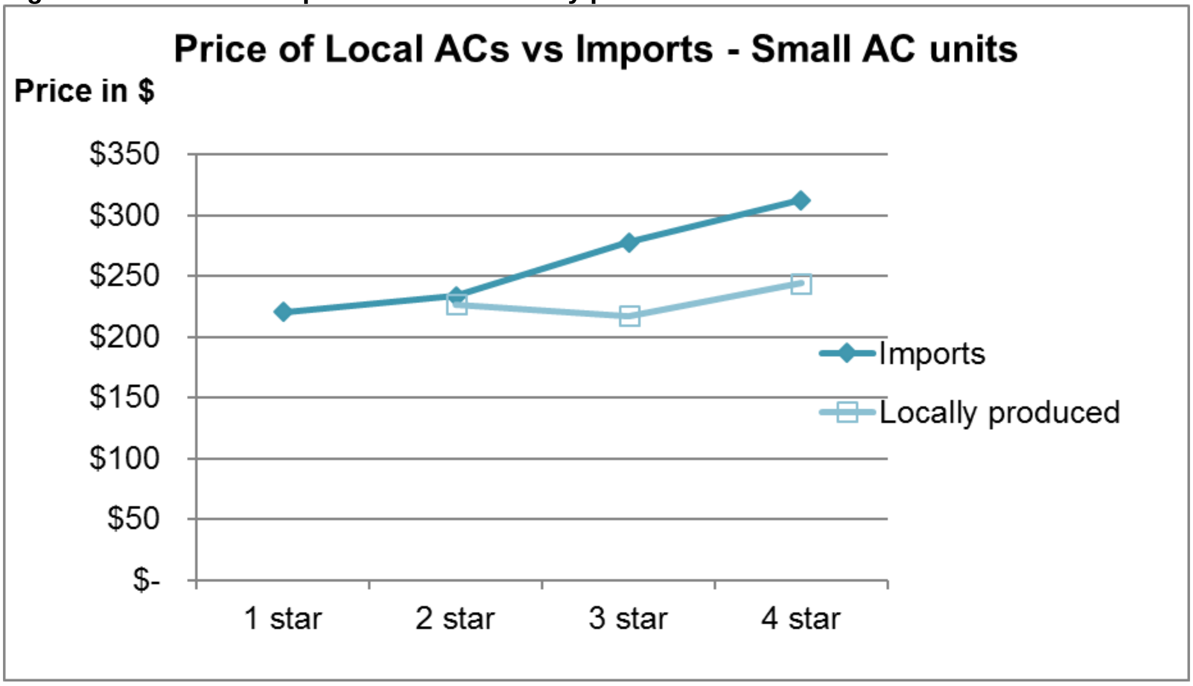
Figure 11 – Efficiency Range by Supplier in the Certification Database



Source :[10] and MEMR certification database

Another interesting finding from IDEA is that the price of ACs produced locally is actually cheaper than ACs that are imported. This remains true at every efficiency level, making local industry quite competitive on the Indonesian market, even at higher efficiency levels. Higher standard would not lessen competitiveness and may even increase market shares of Indonesian products, given their price point. The following figure illustrates this finding for units <12,000Btu/hr, which represent the 98% of the local production.

Figure 12 – Prices of Imported ACs vs Locally produced



Source :IDEA Indonesia

Conclusions and Recommendations

Given that most of the market is already above the four star level, the current and planned regulations for ACs in Indonesia will have no or limited impact. Based on the data we collected and discussions with our partners at MEMR and other ministries, we recommend the following actions (which can take place in parallel):

Re-open the S&L development process for ACs: A signal must be sent to stakeholders and the international community that EBTKE will revise the current planned regulations in light of new evidence from the market. The new process should include technical analysis and quantification of impacts on all stakeholders. The MEPS selection should be based on criteria such as maximization of consumer welfare, national benefit, and no decrease in local industry competitiveness. The label should clearly indicate to consumers which units are high efficiency (these should represent no more than 20-30% of the market).

Stakeholder engagement: A steering committee should be formed including all of the ministries involved in energy and infrastructure planning, finance, and industry.[2] EBTKE needs to assess carefully the barriers and needs relevant to the different stakeholders in order to raise the level of ambition of the S&L program. This can be done through interviews with individual manufacturers. It will be important to include civil society (e.g. consumer association, environmental organization) in stakeholder meetings.

Regulatory reforms: It is important to identify which regulations create barriers to the implementation of energy-efficiency programs. Based on the data we collected, it seems that there is no technical barrier to meeting efficiency standards higher than those currently in effect or planned. Therefore, attention should be focused on regulatory barriers and modifications. For example, the law that imposes taxes on import of components but not on entire units should be reviewed by the steering committee. At the same time, some additional regulations may be needed to enable investment in energy efficiency (assembly-line retooling, consumer programs).

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[2] A similar committee has been recently created to discuss the implementation of a roadmap for appliance energy efficiency to reach a 10-GW savings target by 2025.

Data and analysis: Efforts to build MEMR's capacity to collect and analyze data should be maintained as the S&L program grows. Evidence from the market will be key for market monitoring, verification, and evaluation activities to check that the program is delivering the intended savings, making efficiency a viable resource for Indonesia's energy future.

Given the similarities in markets within the ASEAN region, it is likely that the baseline efficiency and prices presented in this paper are relevant for other economies in the region. In future revisions of the regional ASEAN roadmap, careful consideration should be given to market baselines in order for the program to remove inefficient models and transform the market towards more efficient products. The case of Indonesia and ASEAN is not an isolated case. Many countries tend to be conservative in setting standards because of a lack of market data and impact analyses. We hope that our research has helped draw the attention on this common pitfall and that our tools and analysis will contribute to impactful market transformation programs in Indonesia and around the world.

Acknowledgments

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