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Technical and Economic Feasibility Study for a High Efficiency Compressor Market in Brazil

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Because of its convergence with its mission of promoting prosperity, justice and low carbon development in Brazil, energy efficiency is one of the priorities of the Institute for Climate and Society (ICS). In addition to supporting several organizations working to advance this theme in Brazil, ICS is the coordinator of the Kigali Project, an initiative that is part of the Kigali Cooling Efficiency Program (KCEP), which seeks to increase energy efficiency in the air conditioning sector as contributing to the mitigation of greenhouse gas emissions and reducing the systemic costs of the Brazilian electricity sector, in order to increase productivity and lower energy bills to the final consumer.

One of the strategies of the Kigali Project is to investigate and propose ways of coping with the different barriers to air conditioners with energy efficiency levels in line with international best practices. As part of this work, our initial evaluation was that one of the possible ways would be to leverage investment alternatives for superefficient compressor production lines in Brazil. To assess this issue, we started a partnership with CLASP, one of the most recognized energy efficiency institutions in the world.

As you can see in this study, the reality found in Brazil proves to be more complex, highlighting other more shocking barriers beyond the lack of investment conditions. Indeed, it can be argued that this analysis of the energy efficiency in the compressor sector has shed light on another issue - the interface between industrial and energy policies.

In a domestic scenario in which subsidies and tax incentives become the focus of the political discussion and is one of the main issue to be addressed by the national economy, we believe that the study developed by CLASP can contribute not only to provoking a debate and proposing alternatives to face the regulatory and political problems to the advancement of a market of efficient compressors in the country, but also, at a broader level, to expose the case of the air conditioning sector as an example of the need for a strategic integration between industrial and energy policies.

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ABOUT KIGALI PROJECT

To support countries, businesses and communities in relation to the Kigali Amendment, the Kigali Cooling Efficiency Program - K-CEP was developed. It is funded by international philanthropic foundations and works to enable us to live in a world where cooling is ecologically sustainable, is energy efficient and accessible to all. With these objectives, the program supports institutions, public policies and technological capacity, as well as leveraging funding for these initiatives in several countries. Brazil participates in this program with the Kigali Project with the Institute for Climate and Society (ICS) as the implementing agency.

The Kigali Project has its structure comprised of four components:

- 1 To support the planning of the electricity sector to include energy efficient measures for the air conditioning sector and to relate efficiency with the plan for the reduction of the use of hydrofluorocarbons (HFCs) in air-conditioning equipment.
- 2 To act so that the minimum levels of energy efficiency adopted for air conditioners in Brazil, the Brazilian Labeling Program and the Procel Seal, are revised to get closer to international best practices.
- 3 To contribute to the technological updating and, therefore, to improve the energy efficiency of the sector of compressors in Brazil.
- 4 To contribute to overcome the barriers of energy efficiency in the air conditioning sector. For this, the project provides support for the structuring of test laboratories and also for mechanisms that stimulate the consumer to seek more efficient products and to influence the market.

More on: www.kigali.org.br

ABOUT CLASP

CLASP is a technical non-governmental organization that works worldwide to improve the energy and environmental performance of the appliances & equipment we use every day, accelerating our transition to a more sustainable world. CLASP works hand-in-hand with policymakers, governments, technical experts, industry and others in the supply chain, donor organizations, consumers and consumer groups, and other stakeholders to develop and lead markets towards the highest-quality, lowest resource-intensive products. More on: www.clasp.ngo

1. Executive Summary

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1. Executive Summary

This technical and economic feasibility study evaluates the Brazilian market for air conditioner (AC) compressors, reviews policies that affect cost and/or restrict access to high efficiency compressors, and identifies other economic and technical barriers to their availability in Brazil. Multiple stakeholders have cited the availability of high efficiency and affordable compressors for air conditioning as a barrier to improving the energy efficiency of ACs in Brazil. The goal of this study is to identify viable options to promote a high efficiency compressor market in Brazil, thereby contributing to the transformation of the market towards more efficient ACs.¹

This report is organized and presented in four chapters as follows:

Introduction

Compressor Market Overview

Barriers to High Efficiency Compressors in Brazil

Conclusions and Recommendations

CLASP analyzed the Brazilian AC market and Brazilian trade in AC components to understand the demand for Brazilian-made compressors and the opportunities to incentivize investment in the production of high efficiency compressors at competitive prices. In addition, CLASP reviewed the tax and tariff frameworks that incentivize AC manufacturers to source compressors from domestic suppliers. The main findings of the extensive research and in-person interviews CLASP conducted with numerous stakeholders in Brazil are presented in the Compressor Market Overview and Barriers to High Efficiency Compressors in Brazil chapters, and summarized below. CLASP identified four types of barriers to high efficiency compressor production in Brazil: energy efficiency policy barriers, industrial regulation barriers, financial barriers, and a technical barrier. We found that the financial and technical barriers cannot be readily addressed in the short term. However, opportunities to remove some of the regulatory and policy barriers identified in the study are presented in the Conclusions and Recommendations chapter.

¹ The regulations, including the Basic Production Process (PPB), that affect the compressors market also affect the market for motors for AC units. However, the impact of these regulations on the motors market is beyond the scope of this study. To learn more about regulations affecting energy efficiency in motors in Brazil, please see the International Energy Agency's Energy Efficiency Market Report 2018, which includes a case study on the Brazilian motors market.

An efficient air conditioner market in Brazil is hindered by lagging MEPS and limited availability of high efficiency domestic compressors

The limited availability of locally-produced highly efficient compressors on the Brazilian market has been cited by AC assemblers as one of the primary barriers to them being able to meet higher efficiency standards.² The Brazilian regulations in the Basic Production Process (PPB)³ incentivize AC assemblers to purchase locally-produced compressors. Currently, Tecumseh is the only domestic manufacturer of AC compressors in Brazil. Tecumseh only sells fixed-speed AC compressors, although they have the ability to produce inverter compressors as well. The assemblers hold these are more expensive and less efficient than compressors on the international market. This purported difficulty in meeting higher standards has contributed to Brazilian AC minimum energy performance standards (MEPS) levels significantly lagging behind MEPS levels in other major AC markets.

The Brazilian regulatory environment is challenging for multinational AC companies, which are subject to high tariffs and a set of local content requirements for AC assembly

Brazil has long used its trade policy to promote domestic manufacturing by protecting Brazilian manufacturers from foreign competition through high tariffs on imported goods.⁴ The imported products that face such high tariffs include ACs and AC components. Given the long distance between Brazil and the major AC manufacturing centers in East Asia, the high tariff costs, and the time-consuming process of achieving customs clearance, Brazil has been a challenging market for foreign AC manufacturers. In order to cope with these challenges, many multinational manufacturers have set up factories in Brazil to assemble ACs using imported components. These factories are all located in the Manaus Free Zone, where manufacturers receive various tax exemptions, including tariff exemptions on imported components, so long as they follow the PPB. The PPB is essentially a set of local content requirements for AC assembly in the Manaus Free Zone.

The vast majority of ACs sold in Brazil are assembled domestically by multinational AC companies in Manaus

Multinational AC companies that assemble units in Brazil include Chinese companies such as Midea and Gree, Korean companies such as LG and Samsung, a European company (Electrolux), and a US company (Whirlpool). Japanese companies such as Fujitsu and Daikin are also present in the market, though with a much smaller market share than those companies mentioned above. In addition, some local companies, such as Elgin, also assemble ACs in Brazil. Brazil imported less than 100,000 units in 2017, or less than 2% of the total units sold in the country.

² Shores 2017

³ The Basic Production Process (PPB) is a set of requirements that AC assemblers must follow in order to receive the tax benefits associated with the Manaus Free Zone. These requirements include purchasing a minimum percentage of certain components, including compressors and motors, from domestic sources. For example, 30% of compressors and 40% of motors for split AC units must be sourced domestically

⁴ Ramnauth 2017

The Basic Production Process (PPB), which regulates production in Manaus and thus governs the AC assembly industry, requires assemblers to purchase a share of their compressors from national manufacturer

The AC assembly industry in Manaus is governed by the PPB, which is designed through a complicated process of negotiations between the Ministry of Development, Industry and Foreign Trade (MDIC), AC assemblers, and local AC component manufacturers. A significant share of the Brazilian AC compressor market is reserved for Tecumseh, taking into account that this company is the only one that meets PPB requirements. Tecumseh's high value-added production process and substantial contribution to employment in Sao Carlos in Sao Paulo State matches the required goals of PPB design, such as generation of employment, local technological development, and equilibrium between regions of the country. For mini-split ACs, assemblers must purchase 30% of rotary and reciprocating compressors under 18,200 Btu/hr from a domestic manufacturer.⁵ For window ACs, 50% of the compressors must come from a domestic manufacturer. The exception to these rules is that manufacturers who only produce inverter mini-splits are not currently required to purchase compressors from a domestic manufacturer, but must dedicate 3% of their revenues to research and development (R&D, or referred to in Portuguese as pesquisa e desenvolvimento, or P e D).⁶

The PPB restricts access to well-established international supply chains for cheaper and more efficient compressors

The requirement to purchase locally-produced compressors forces AC assemblers to modify their AC unit designs to incorporate Tecumseh's products, as opposed to compressors they would normally source from international markets. AC assemblers see the PPB as necessary, although they do not agree with many of its provisions. On one hand, the tax incentives related to the Manaus Free Zone are generally recognized as crucial to the development and survival of the Brazilian AC industry. Similarly, it is generally understood that there would be no tax incentives without the PPB, as a domestic supply chain is a key justification for the granting of these incentives. On the other hand, the assemblers would prefer not to buy Tecumseh's compressors, as most of them are large multinationals with well-established international supply chains for compressors, and several of the AC companies also produce high efficiency compressors at major manufacturing bases in East and Southeast Asia. Furthermore, domestic AC assemblers argue that Tecumseh's compressors are more expensive and lower quality than the compressors available on the international market, though Tecumseh disputes these claims and holds that AC assemblers have not tested the latest and most efficient inverter compressor that they have developed.

Brazil's industrial and energy efficiency policies limit availability of high efficiency compressors in the country

The PPB, the tax and tariff framework, and the existing energy efficiency policy account for the main barriers to highly efficient inverter compressors in the Brazilian market:

⁵ Diário Oficial da União 2014

⁶ Companies who only produce split ACs with imported inverter compressors are allowed to receive the tax incentives for producing in Manaus if they dedicate 3% of revenue from AC sales to R&D. This R&D may occur within the company or the company may choose to hand over the R&D funds to one of the research institutions selected by the Superintendent of the Manaus Free Zone (SUFRAMA). The few companies who have chosen to switch to only producing inverter compressors use the R&D money for improving their own production processes. The internal R&D projects must be approved by SUFRAMA

- **It is not cost-effective to import high efficiency compressors,** unless a manufacturer only produces inverter ACs, due to high tariffs, taxes and the regulations surrounding the Manaus Free Zone. These policies are unlikely to change dramatically in the near term, as they represent decades of Brazilian industrial policy which has incentivized billions of dollars of investment in the country, particularly in the Zona Franca de Manaus.
- **The Brazilian AC market is not large enough to justify new investments in the production of high efficiency compressors outside of the current domestic producer.** The impossibility of achieving economies of scale in compressor production in Brazil is largely due to the lack of an export market. ACs produced in Brazil are not competitive in international markets due to their high cost of production. The complicated logistics and costs associated with transporting components and finished products in and out of Manaus adds substantial costs to AC production in Brazil, since Manaus is in the heart of the Amazon rainforest and approximately 1,300 km up the Amazon River from the Atlantic coast. Furthermore, the requirements of the Basic Production Process, including local content requirements for both compressors and motors, add to the cost of AC production in Brazil. Several multinational AC companies revealed that they had investigated the possibility of investing in an AC compressor factory in Brazil, but found that such an investment would not be financially viable because of these issues.
- **The low MEPS levels have not moved the market to higher efficiency products and have given AC assemblers the option to produce inefficient products.** AC assemblers and component manufacturers generally agreed that the recent increase in the MEPS level to an energy efficiency ratio (EER) of 3.02 W/W would not lead to any significant changes in the market because nearly all products currently being produced exceed that efficiency level.
- **Weak labeling criteria has prevented consumers from being incentivized to purchase high efficiency AC units.** Brazil has not significantly re-scaled the comparative energy label for ACs in nearly a decade, leading to little differentiation between highly efficient and less efficient ACs. This lack of differentiation gives consumers no easy way of identifying high efficiency products, which limits the demand for such products. Without demand for high efficiency products, manufacturers have little incentive to significantly improve the efficiency of their products.
- **The antagonistic relationship that exists between Tecumseh and some AC assemblers has hindered the cooperation needed to deploy AC units that effectively use Tecumseh's inverter compressors.** Tecumseh reports that they have built a production line for inverter compressors, but that this production line is inactive because no AC assembler has placed an order for these compressors. Tecumseh's inverter compressors require softwares for those compressors; however, AC assemblers insist that Tecumseh should design inverter compressors for each assembler's AC unit design. The lack of dialogue between the AC assemblers and Tecumseh has prevented the two sides from resolving this issue and there are currently no inverter AC units produced in Brazil that use locally-produced compressors. Instead of directly communicating amongst themselves, as is normal in commercial relationships throughout the world, the relationship between national components manufacturers and the AC assemblers is mediated by the Brazilian Federal Government, through the PPB.

Addressing some of these barriers in the short term could be achieved by revising the PPB and updating energy efficiency standards and labeling policy

Some of the barriers to the widespread availability and utilization of high efficiency compressors will prove difficult to address. The system of tax incentives and the PPB is unlikely to be eliminated or dramatically restructured as billions of dollars of investments have been made based on the existing policies. These investments include large industrial facilities that employ thousands of people. Changing the system in a way that would lead to the loss of these jobs, at a time when Brazilian unemployment is near an all-time high at over 13%, would be difficult to justify.⁷ It is unlikely that the market for Brazilian-made ACs can grow to justify large investments in new compressor production lines, as the production in Manaus under this system is not internationally competitive, rendering significant exports unlikely. Furthermore, the Brazilian domestic AC market is unlikely to expand rapidly as Brazil is only just beginning to recover from its recent economic crisis, and the International Monetary Fund predicts Brazil's economic growth to remain under 3% for the foreseeable future.⁸

Given that the PPB is unlikely to be eliminated and the market is unlikely to grow rapidly, the remaining options for addressing the barriers to high efficiency compressors revolve around energy efficiency policy and more subtle adjustments to the PPB.

Based on all of the key findings noted above, CLASP recommends:

- **Increasing AC MEPS to encourage industry to resolve existing issues in the compressor market.** Specifically, a timeline or road map for increasing MEPS over the coming decade would give companies a clear signal of the need to invest in efficiency to ensure that their products can meet the coming higher MEPS, and provide them with sufficient notice to work through the challenges in the compressor market (for instance, resolve the compatibility issues with Tecumseh-produced inverter compressors).
- **Moving to MEPS based on a test method and metric that includes part-load performance would capture the benefits of inverter compressors,** which can use as much as 21% less energy by operating at part load instead of switching on and off.⁹ The current test method does not capture these benefits as it only tests AC units at full load. This would, in turn, incentivize an accelerated shift to using inverter compressors as their efficiency benefits would be reflected in the standard. Several AC assemblers expressed strong support for much more stringent MEPS using a test method that includes part-load performance.

⁷ Federowski 2018

⁸ IMF 2018

⁹ EuP 2009

- **Re-scaling the Brazilian AC label to support improvements in efficiency.** The energy efficiency criteria for ACs under the Brazilian labeling program has remained stagnant for the past decade and most of the ACs in the market are “A” class, regardless of their overall efficiency. In order to drive the market towards more efficient ACs, the Brazilian energy label should be re-scaled such that products in the market once again have a range from A to D or E, with the A level sufficiently high to only include the most efficient 15%-25% of products on the market. This would also give the Selo PROCEL endorsement label more meaning, as it currently is applied to any unit meeting the ‘A’ level. It may also be worth considering separating the Selo PROCEL from the A-E labeling program so that it can be revised independently in order to always distinguish the highest efficiency products. The combined effect of these two changes to the labeling system and the move to a test metric that includes part-load performance would be an increased incentive for consumers to purchase more efficient AC units, particularly those using inverter compressors.

CLASP has these additional recommendations, but with a lower likelihood of implementation and/or some noteworthy drawbacks:

- **Moving to a flexible, points-based PPB would allow manufacturers to avoid buying inefficient components while maintaining the requirement to have a domestic supply chain.** Originally, the PPB was based on a points system, wherein purchasing a specific component from a domestic supplier gave the manufacturer a specific number of points toward meeting the minimum number of points required to receive the tax incentives. Such a flexible system allows each manufacturer to choose to meet the PPB in the most efficient way and to avoid purchasing components that would be incompatible with product efficiency standards. This could help manufacturers meet updated efficiency standards even if a specific local component, such as the compressor, is unable to meet the standard, as it provides flexibility to purchase locally-produced components that allow them to meet the standards at the lowest possible cost.
- **Including efficiency criteria in the PPB would create a direct incentive for improved efficiency.** For example, the PPB could state that only ‘A’ class equipment can receive tax incentives, while taxes must still be paid on other equipment. This could be particularly valuable as manufacturers noted the impossibility of creating further tax incentives for efficient equipment when the tax is already 0%. This would also incentivize manufacturers to only, or primarily, assemble ‘A’ class equipment and would increase the market price of less efficient equipment. However, such a strategy would add yet another economic distortion to the already highly distortionary Manaus Free Zone and PPB system, and would likely lead manufacturers to strongly oppose any label rescaling as it would reduce the share of their products that is eligible for tax incentives.
- **Redirecting the required R&D spending from assemblers who only produce inverter units to AC energy efficiency could create a financial resource for improving efficiency.** For example, the PPB could require that manufacturers use this resource to invest in R&D for more efficient products or for the creation of more efficient compressor production lines in Brazil. The challenge for this approach is that only a handful of manufacturers have opted to move to producing only inverter units, meaning that the pool of R&D funding is relatively small. Manufacturers generally believed that the 3% R&D requirement would not provide sufficient funding to develop new products. In addition, this funding would depend on the continued existence of the 3% R&D requirement in the PPB, which would naturally disappear if the MDIC were to approve Tecumseh’s request for a requirement to purchase domestically-produced inverter compressors.

2. Introduction

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2. Introduction

Compressors are typically the most energy consumptive component of air conditioners (ACs). For this reason, high efficiency compressors are indispensable for the production and sale of high efficiency ACs. In particular, inverter compressors significantly improve AC efficiency by allowing the AC unit to run at part load as opposed to switching on and off, as is the case with fixed speed ACs. The efficiency gains resulting from switching to high efficiency fixed speed compressors would be approximately 15%, while the efficiency gains from switching to high efficiency inverter compressors would be around 21%.¹⁰

This technical and economic feasibility study was carried out to evaluate the Brazilian market for AC compressors, identify policies that affect cost and/or restrict access to high efficiency compressors, and identify other economic and technical barriers to their availability in Brazil. This study was funded by the Instituto Clima e Sociedade as part of the Kigali Cooling Efficiency Program (K-CEP), which has the goal of improving efficiency in cooling products around the world in order to maximize the climate benefits of the phasedown of high global warming potential (GWP) HFC refrigerants under the Kigali Amendment to the Montreal Protocol.

The limited availability of locally-produced high efficiency compressors on the Brazilian market has been cited by AC manufacturers as one of the primary barriers to them being able to meet higher efficiency standards.¹¹ The Brazilian regulations incentivize AC assemblers to purchase locally-produced compressors, which the assemblers claim are more expensive and less efficient than compressors on the international market. Currently, there is only one domestic manufacturer of AC compressors, Tecumseh, who only sells fixed-speed compressors, though they have the ability to produce inverter compressors. This purported difficulty in meeting higher standards has contributed to Brazilian AC minimum energy performance standards (MEPS) levels significantly lagging behind MEPS levels in other major AC markets.

CLASP analyzed the Brazilian AC market and Brazilian trade in AC parts in order to understand the demand for Brazilian-made compressors and the opportunities to grow sales through production of high efficiency compressors, in addition to the tax and tariff frameworks that incentivize AC manufacturers to source compressors from domestic suppliers.

CLASP conducted extensive research and in-person interviews with a variety of stakeholders in Brazil that are involved in the production or regulation of ACs in Brazil, including several AC manufacturers, AC manufacturer associations (ABRAVA and ELECTROS), the domestic AC compressor manufacturer (Tecumseh), the Brazilian Program for the Conservation of Electricity (PROCEL), and government officials from the Ministry of Mines and Energy (MME), the Ministry of Development, Industry, and Trade (MDIC), and the Superintendent of the Manaus Free Zone (SUFRAMA). A full agenda of meetings held with these entities can be found in **Appendix A**.

¹⁰ EuP 2009

¹¹ Shores 2017

3. Compressor Market Overview

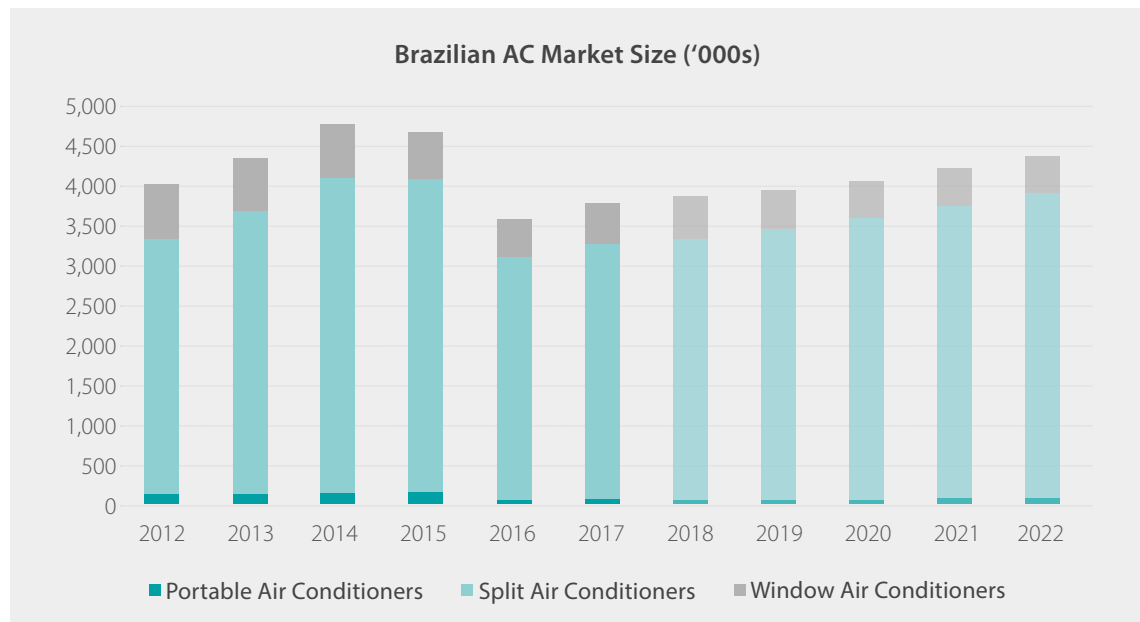
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3. Compressor Market Overview

3.1 AC Market Demand

Brazil has a relatively large AC market, with approximately 3.7 million units sold in 2017, making it the fifth largest market for room ACs in the world¹². This large market size is the result of the tropical and subtropical climates covering most of the country and its status as a middle-income country, which means many consumers are able to purchase appliances such as ACs. The market also has significant space to grow: AC companies operating in the country estimated that household AC penetration was only 15-20%.

Figure 1: Brazil AC Market Size 2012-2022



The Brazilian AC market shrank in 2015 and 2016, interrupting a longer-run trend of rapidly increasing AC sales. This sudden contraction of the AC market reflected the larger economic crisis that Brazil has been facing since 2014. As the country begins to emerge from this crisis, the economy is starting to grow again, allowing the 2017 expansion of the AC market¹³. This expansion is projected to continue through 2022, though it is not expected to result in as large of an AC market as existed before the crisis, in 2014.

There is little reason to believe that AC market growth might exceed these projections. The IMF forecasts that Brazil's economic growth for the next five years will remain between 2.2%-2.5% as the economy faces significant challenges related to low commodity prices, rising government debt, and hesitance to implement necessary economic and fiscal reforms¹⁴. The effect of these challenges and the low projected economic growth is that AC manufacturers are hesitant to invest in the country and consumers are unlikely to see significant real income increases in the coming five years. The lack of income increases will hold back growth in appliance consumption, including AC sales.

¹² Euromonitor 2018

¹³ JARN 2018

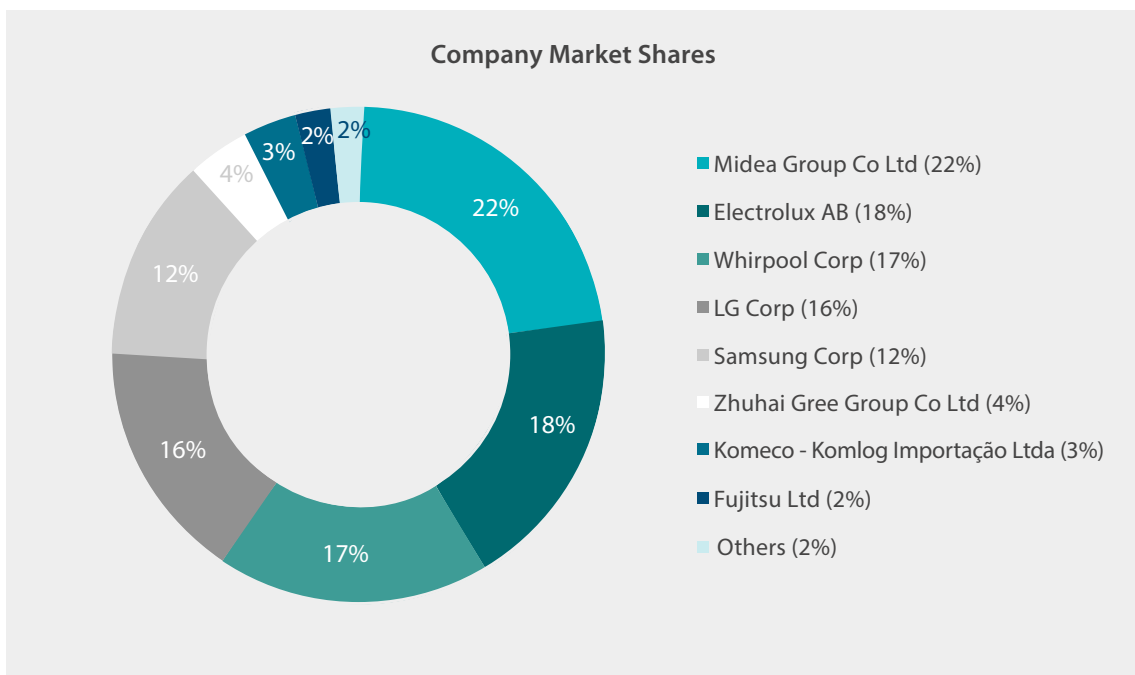
¹⁴ IMF 2018

3.2 AC Market Supply

The vast majority of ACs sold in Brazil are assembled domestically by multinational AC companies. These include Chinese companies such as Midea and Gree, Korean companies such as LG and Samsung, a European company (Electrolux), and a US company (Whirlpool). Japanese companies such as Fujitsu and Daikin are also present in the market, though with much smaller market shares than those companies mentioned above. Daikin is the newest entrant into the market, having opened an assembly plant in Manaus in 2014, which is currently producing around 70,000 units a year, with more growth planned. There are also a handful of local AC companies, such as Elgin, who participate in AC assembly in Manaus.

Brazil imported less than 100,000 units in 2017, or less than 2% of the total units sold in the country. A major reason for the low number of imports is that the tariff rates for imported assembled ACs range from 14%-20% and imported AC components including compressors attract tariffs ranging from 14%-18%¹⁵. In addition, the industrial product tax (IPI) for AC units that are imported or produced outside of Manaus is 35%¹⁶. Units produced in the Manaus Free Zone are not subject to this tax, and assemblers receive an exemption from the tariffs for imported components so long as they follow the Basic Production Process (PPB), described at the end of this chapter. Though the AC assemblers in Brazil do supply nearly the entire Brazilian market, they export very few units.

Figure 2: Brazilian Market Shares by Company¹⁷



The companies with the largest market shares in Brazil all have local assembly facilities in Manaus. The choice of Manaus as the location for these AC assembly facilities is due to its status as a Free Trade Zone, with significant tax and tariff benefits for industrial companies, as detailed in the section on the PPB. The companies with the largest market shares are also the same companies that have the largest share of domestic AC production, with Midea, Electrolux, LG, Samsung and Gree accounting for nearly 75% of production, and other major brands such as Whirlpool producing in Manaus as well. This is noteworthy because it shows that AC companies are marketing and distributing ACs under their own brands, with relatively few original equipment manufacturers (OEMs) producing ACs to be sold under other brands.

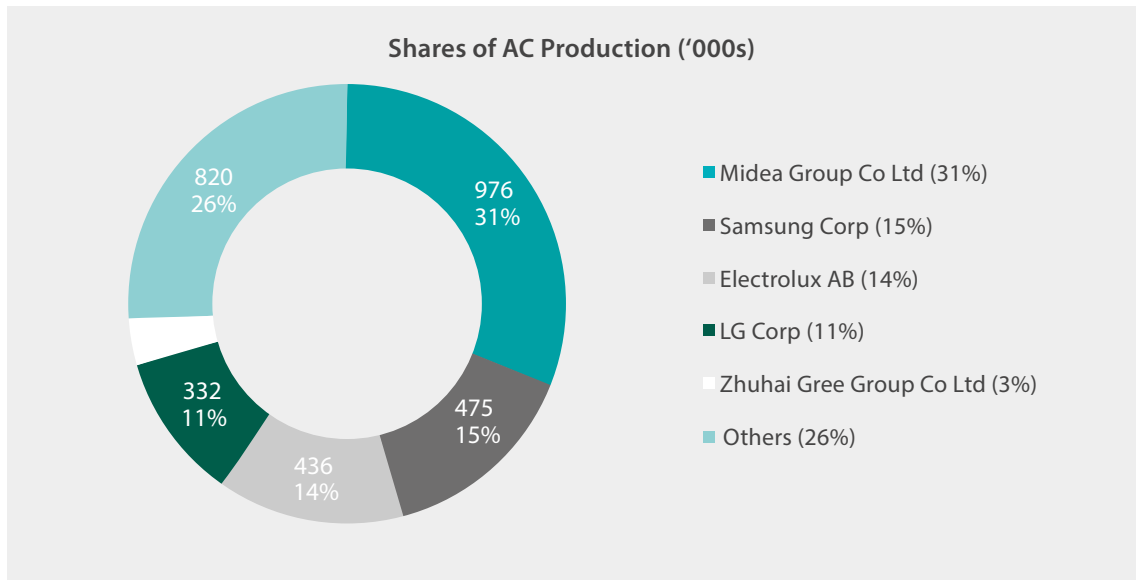
¹⁵ WTO 2018

¹⁶ JARN 2018

¹⁷ Euromonitor 2018

The Brazilian AC industry has two main associations: ABRAVA and ELECTROS. ABRAVA has a broader membership within the cooling sector, including the AC assemblers, Tecumseh, and various installation and servicing companies. ELECTROS is the association of appliance manufacturers, with a white goods division that includes all of the major AC assemblers operating in Brazil, with the exception of Gree.

Figure 3: Brazilian AC Assembly by Company ¹⁸



AC Market Composition

The AC market is currently dominated by split units, with the market share of portable units and window units decreasing since 2012. As of 2013, 80% of mini split units and 100% of window units sold in Brazil used R-22 as the refrigerant, with only 20% of mini-splits using R-410A and no units using any low global warming potential (GWP) refrigerants¹⁹. The trend since 2013 has been a shift from R-22 to R410A, though updated data on the market share of each refrigerant is not yet available²⁰.

In the coming years, there is likely to be a continuation of the R-410A trend, with a new plant to produce R-410A having just opened in Manaus last year. In the planned shift towards lower-GWP refrigerants, Daikin is beginning to sell ACs using R-32 later in 2018 with a full shift to R-32 planned by 2020. Other AC assemblers expressed concern about the possibility of using any form of flammable refrigerant, including R-32 or R-290, in Brazil due to the safety risks that could result from such refrigerants being used by unqualified installation technicians.

3.3 AC Compressor Demand

Compressor Market

The AC market size of 3.7M units a year translates almost directly into a demand for 3.7M compressors, as each AC unit requires a compressor and relatively few AC units are imported. Similarly, trends in the AC market should translate into trends in the compressor market, albeit with some amount of lag as AC producers cut production in response to declining sales or clear inventories before increasing production to meet growing demand.

¹⁸ Euromonitor 2018

¹⁹ Programa Brasileiro de Eliminacao dos HCFCs 2016

²⁰ R-22 is an ozone depleting substance (ODS) with a 100 year GWP of 1,810 times carbon dioxide. R-410A is not an ODS but it has a GWP of 2,088, while R-32 has a GWP of 675 and R-290 has a GWP of less than 3.

According to various AC companies, inverter units account for between 30% and 40% of all split units sold, with few inverter window units sold. The share of inverter ACs in the market has been steadily increasing over the past few years and most companies interviewed believed that this trend would continue, though there were varying opinions on whether inverter ACs would ultimately come to dominate the market. Notably, LG and Daikin produce and sell only inverter ACs in Brazil, and Samsung is similarly transitioning to only selling inverter units.

Domestic Supply

The only AC compressor manufacturer in Brazil is Tecumseh Brazil, a subsidiary of Tecumseh Products Company, a US company based in Ann Arbor, Michigan. Tecumseh Products Company was founded in 1934 and the Brazilian subsidiary was founded in 1972. Through operations in the US, France, Malaysia, India, China, and Brazil, Tecumseh produces a wide variety of compressors using various refrigerants and covering a large range of efficiencies.

In Brazil, AC compressors account for approximately important share of compressor sales, with approximately 900,000 units sold in 2017²¹. These sales are of fixed-speed compressors for both split-type ACs and window units, with sales rising for compressors using R-410A and declining for compressors using R-22. Tecumseh executives stated that they currently possess a production line for inverter compressors, with a capacity of 100,000 compressors per year; however, this line is inactive as no AC assembler has placed an order for Tecumseh's inverter compressors. According to Tecumseh executives, this may change in the future, as one large AC producer is currently testing Tecumseh inverter compressors. Tecumseh expressed openness to producing compressors with lower-GWP refrigerants such as R-290 or R-32, so long as market demand exists.

Beyond room AC compressors, the remaining Tecumseh's business in Brazil consists of compressors for other applications ranging from refrigeration to automobile air conditioning. Approximately 40% of these products are exported and none of these other products are destined for markets regulated by a 'Basic Production Process' (PPB), as is the case of the AC compressor market, as detailed below.

Tecumseh's Brazilian operations are substantial. They are a cornerstone of the economy of Sao Carlos, a city in Sao Paulo State, where they employ nearly 3,000 people directly and approximately 10,000 people indirectly throughout their supply chain. Their operations in Sao Carlos consist of two large factories with a highly vertically-integrated process that includes a forge, stamping machine, machining process, assembly, tests and packing of compressors and accessories. In addition, all R&D for Tecumseh's Brazilian product line is done in Brazil. Notably, some of Tecumseh's R&D is done with the support of the Funding Authority for Studies and Projects (FINEP).

Other Domestic Manufacturers

Aside from Tecumseh, there are two other compressor manufacturers operating in Brazil: Embraco and Danfoss. However, neither company manufactures compressors for ACs at this time. It is possible that Embraco may undergo some changes in strategy and focus, as it was just acquired by Nidec, a Japanese company that makes components for ACs, among other products²².

Several of the AC assemblers operating in Brazil have considered or are considering investing in local AC compressor production. According to these companies, the primary challenge that they have faced in seeking to invest in compressor production is that the market size is not large enough to generate the economies of scale necessary to produce compressors at a competitive price. This low competitiveness combined with the small projected sales volume would make it difficult to see an attractive return on any investment in compressor production, even with low-cost financing.

²¹ Meeting with Tecumseh Executives in Sao Carlos. August 9, 2018

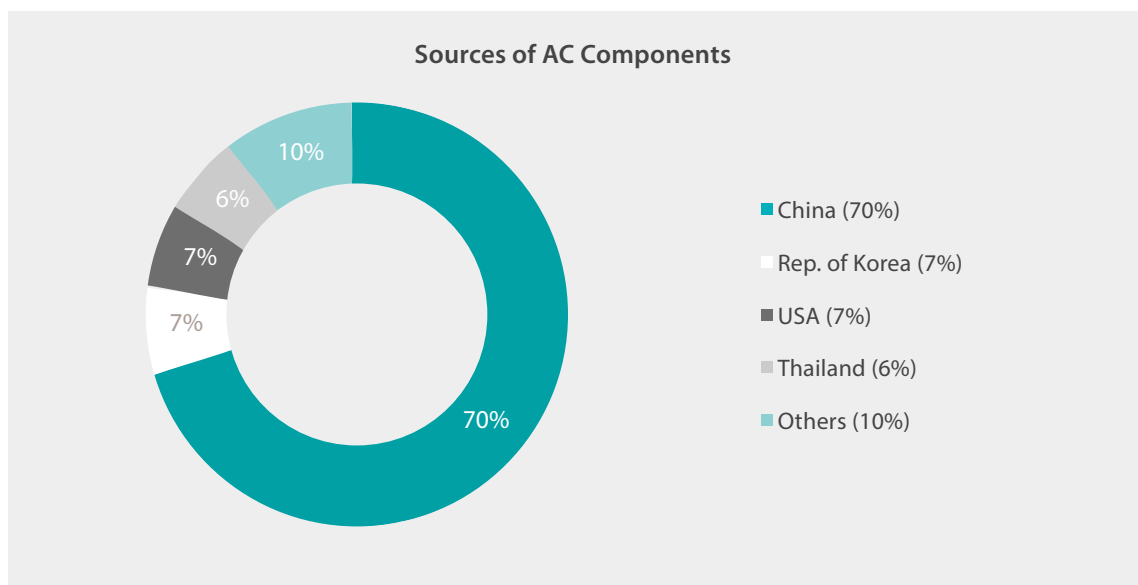
²² Nidec 2018

Imports

Aside from the portion of the market served by Tecumseh, all other AC compressors are imported. This includes all rotary and reciprocating compressors with a capacity over 18,200 Btu/hr, variable speed compressors, and scroll compressors, as these are not currently produced in Brazil²³. In total, Brazil imported US\$378M of components for ACs in 2017. These imports came primarily from China, though noteworthy quantities of imports also came from Korea, the US, and Thailand²⁴.

LG, Samsung, and Daikin import all of their compressors because they only produce inverter ACs, which fall under different rules in the PPB explained below. When visiting Daikin's assembly plant in Manaus, CLASP observed that all of the compressors being used in their ACs were imported from Daikin's operations in Thailand.

Figure 4: Sources of Air Conditioner Components²⁵



Daikin is not the only company importing AC components from their parent company. In many cases, the AC assemblers import near-complete AC kits, including compressors, produced by their parent company overseas. AC components, when imported outside of the specified rules for the Manaus Free Zone, face import tariffs of 14%-18%. Receiving an exemption from this import tariff is an important reason for assemblers to locate their production in Manaus.

3.4 Regulation Affecting the Compressor Market

Brazilian Industrial Policy

Brazil has long used its trade policy to promote domestic manufacturing by protecting Brazilian manufacturers from foreign competition through high tariffs on imported goods²⁶. The imported products that face such high tariffs include ACs, as detailed in the previous section. Given the long distance between Brazil and the major AC manufacturing centers in East Asia, the high tariff costs, and the time-consuming process of achieving customs clearance, Brazil has been a challenging market for East Asian AC exporters. In order to cope with these challenges, many multinational manufacturers have set up factories in Brazil to assemble ACs using imported components. These companies include Midea, Electrolux, LG, Samsung, Gree, Whirlpool, and Daikin.

²³ Diário Oficial da União 2014

²⁴ UN 2018

²⁵ Ibid

²⁶ Ramnauth 2017

In addition, Brazil has many local content requirements for various products, including ACs, and products meeting those local content requirements face more favorable tax treatment. These local content requirements have, however, been subject to several trade disputes, with a WTO panel ruling in August 2017 that the local content requirements for several industries in Brazil violate WTO rules²⁷. It is unclear whether this ruling will lead to changes in the requirements for ACs, as the parties that brought the case against Brazil to the WTO were primarily focused on the local content requirements in the automobile and electronics industries²⁸. As of September 2018, there has been no change to the policies affecting ACs.

In Brazil's defense of its local content requirements before the WTO panel, Brazilian representatives cited Article XX of the General Agreement on Tariffs and Trade (GATT), which allows for significant leeway in complying with WTO rules if the deviations from the rules are made to protect the environment. One of the main justifications for creating the Free Zone has been to shift the Amazon region away from an agricultural economy in order to avoid large-scale deforestation. Although this argument was not found to be compelling in this case, it may prove relevant for any future case involving the Manaus Free Zone.

The most important set of tax and tariff policies for ACs relates to the Manaus Free Zone (Zona Franca de Manaus), where the vast majority of the country's AC production takes place. Companies assembling ACs in the Manaus Free Zone receive an exemption from several taxes, including import tariffs and the industrial products tax (IPI), so long as they follow the prescribed "Basic Production Process" (PPB).

Basic Production Process (PPB)

There are two PPBs affecting AC production: the PPB for mini-split ACs and the PPB for window ACs. The PPBs include provisions regarding the share of Brazilian content in the compressors, motors, condensers, and other components of ACs. By law, the PPBs must be designed based off four criteria:

- 1 Seeking inter-regional equilibrium, avoiding the relocation of factories already operating in the country.
- 2 Increasing the added value in production and attracting investments in order to increase the level of industrial competitiveness and productivity in the country.
- 3 Contribution to the attainment of the over-arching goals of the Productive Development Policy²⁹.
- 4 Increasing employment in the region involved

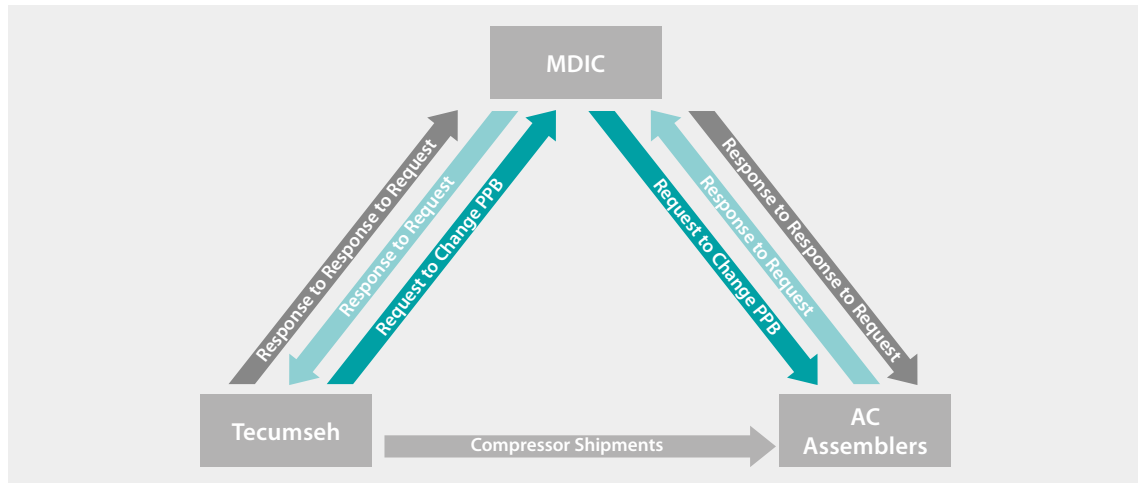
The process for establishing the PPBs is ad hoc and flexible, typically beginning when one participant in the AC component market makes a request for the PPBs to be changed. This request goes to the Ministry of Development, Industry, and Trade (MDIC), who then presents the request to other participants in the market. This begins an iterative process of proposals and counter-proposals, arbitrated by the MDIC. The process for compressors is described in Figure 5.

²⁷ WTO 2017

²⁸ Ibid.

²⁹ The Productive Development Policy was last published in 2011, during the presidency of Dilma Rousseff, and is likely to be updated by the new president to be elected later this year. The 2011 policy includes over-arching goals of promoting innovation and technological development, creating and strengthening critical competencies of the national economy, increasing the productive and technological density of supply chains, broadening the domestic and international markets of Brazilian companies, and guaranteeing socially inclusive and environmentally sustainable economic growth

Figure 5: Relationship between MDIC, Tecumseh and AC Assemblers ³⁰



The result of the PPB design process is that a significant share of the Brazilian AC compressor market is reserved for national manufacturer. This is because Tecumseh's high value-added process and substantial contribution to employment in Sao Carlos match the required goals of PPB design, as described above. For mini-split ACs, assemblers must purchase 30% of rotary and reciprocating compressors under 18,200 Btu/hr from a local manufacturer, of which Tecumseh is the only one ³¹. For window ACs, 50% of the compressors must come from national manufacturer.

There is an important exception to the 30% requirement for mini-split compressors. In 2014, AC assemblers were able to convince MDIC that Tecumseh's inverter compressors were not suitable for their needs. In response, MDIC has allowed companies who only produce split ACs with inverter compressors to continue to receive the tax incentives for producing in Manaus if they dedicate 3% of revenue from AC sales to research and development (R&D). This R&D may occur within the company or the company may choose to hand over the R&D funds to one of the research institutions selected by the Superintendent of the Manaus Free Zone (SUFRAMA). Most of the companies who have chosen to switch to only producing inverter compressors use the R&D money for improving their own production processes. The internal R&D projects must be approved by SUFRAMA ³².

Since 2014, Tecumseh has invested in improving its inverter compressors and launched two new versions of its inverter compressor. However, these technologies have not been tested by AC assemblers yet.

AC assemblers have a complicated relationship with the PPB. On one hand, the tax incentives related to the Manaus Free Zone are generally recognized as crucial to the survival of the Brazilian AC industry. Similarly, it is generally understood that there would be no tax incentives without the PPB, as a domestic supply chain is a key justification for the granting of these incentives. On the other hand, the assemblers would prefer not to buy Tecumseh's compressors, as most of them are large multinationals with well-established international supply chains for compressors, and several of the AC companies also produce compressors overseas. Furthermore, AC producers argue that Tecumseh's compressors are more expensive and lower quality than the compressors available on the international market. The result of this situation is that the PPB is seen as necessary, even if the assemblers do not agree with many of its provisions.

³⁰ Adapted from a presentation by Homero Cremm Busnello of Tecumseh

³¹ Diário Oficial da União 2014

³² Ibid.

4. Barriers to High Efficiency Compressors in Brazil

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4.1 Regulatory Barriers – the Basic Production Process

The PPB has been identified as a particular barrier to energy efficiency, as several AC assemblers have claimed that locally-manufactured compressors are not as efficient as those manufactured in and can be imported from other countries such as China and Thailand³³. This complaint has been echoed by individual assemblers CLASP interviewed, who often claimed that the locally-manufactured compressors are less efficient, lower quality, and higher-priced than the imported compressors.

Tecumseh disputes the assertion that their products are substantially more expensive or less efficient than the imported compressors. They hold that they have been improving the efficiency of their compressors in line with international trends, and that their prices are similar to international prices, with the cost of shipping to Manaus being a major factor in any increased cost for purchasing their compressors as opposed to imported compressors³⁴. Instead, they argue that AC assemblers are producing equipment that does not optimize overall efficiency and does not achieve the full efficiency potential of their compressors. This would be because the AC assemblers import AC kits that were designed for another compressor, but then they assemble these kits in Brazil with the Tecumseh compressor substituted in, instead of designing their ACs for Tecumseh compressors.

4.2 Investment Barriers – Lack of Economies of Scale

The fundamental economic barrier to investment in the production of high efficiency compressors in Brazil is the lack of economies of scale. With less than 4 million units sold a year, the Brazilian AC market is not large enough to justify multiple competing compressor manufacturers, because the compressor sales volumes are unlikely to allow manufacturers to recover their investment. Furthermore, this lack of economies of scale will keep production costs higher than at much larger compressor plants in East Asia; this fact was cited by Tecumseh executives as justification for their perceived inability to sell rotary compressors at internationally competitive prices.

The difficulty of achieving economies of scale in compressor production in Brazil is largely due to the lack of an export market for ACs. The location of AC manufacturing in Manaus, in the heart of the Amazon rainforest and approximately 1,300km up river from the coast, adds substantial costs to AC production in Brazil, primarily due to complicated logistics. For example, according to Tecumseh, it costs between \$1.68 and \$2.16 to ship a compressor from Shanghai to Manaus, while it costs between \$1.96 and \$3.33 to ship a compressor from Sao Carlos to Manaus. Furthermore, the requirements of the PPB, including both the compressor and motor requirements, add to the cost of AC production in Brazil. Altogether, the result is that ACs produced in Brazil are not competitive in international markets because of their high cost of production.

Beyond the barrier presented by the lack of economies of scale, many multinational AC manufacturers

³³ Shores 2017

³⁴ Manaus is nearly 4,000 kilometers from Sao Carlos by road. These roads are also often in poor condition and pass through very isolated areas. As a result, transporting compressors from Sao Carlos to Manaus by road is time consuming and expensive. It is less costly, though more time consuming, to send the compressors by truck from Sao Carlos to the port of Santos, then by ship 4,000km up the coastline to Belem, then by river barge 1,300km to Manaus.

are disinterested in investing in compressor production in Brazil as it would run contrary to worldwide corporate organization plans. Most of the major AC companies who would invest in compressor manufacturing already possess compressor plants in other countries and would prefer to increase production volumes at those facilities in order to achieve greater economies of scale. Investing in a small compressor factory in Brazil would hamper this strategy by moving some of the production at the company's central compressor factory to Brazil, which would increase the company's average per-unit cost of production.

The challenges associated with an investment in highly efficient compressor production in Brazil are highlighted in the financial model that accompanies this study.

4.3 Policy Barriers - AC Efficiency Standards and Labeling

The lack of an ambitious efficiency policy to drive the AC market to higher efficiencies is one of the main barriers for improving energy efficiency of AC compressors in Brazil. The recently-announced update of the MEPS for ACs to an energy efficiency ratio (EER) of 3.02 W/W is widely believed by AC companies to have essentially no effect on the market.

In addition, the labeling program provides little incentive for producers to seek improvements in efficiency, as all products meeting the new MEPS are either 'A' or 'B' class, with relatively few 'B' class models still in the market. With most models already meeting the 'A' class requirement of a 3.23 EER, producers have little incentive to invest in R&D or new production lines for higher-efficiency ACs. New products would not be differentiated in the market, but rather placed in the same category as existing products.

There has no major revision of the labeling program in the past decade nor any major rescaling of the labeling categories. The most recent rescaling of the label in 2013 revised the 'A' level from 3.20 EER to 3.23 EER, an increase of less than 1%, as can be seen in Figure 6. Prior to that revision, the 'A' level had not been revised since 2009. The lack of revisions to the 'A' level also impacts the Selo PROCEL, as the current requirement for the seal is to meet the 'A' level criteria. This contrasts starkly with the labeling revisions in other major AC markets such as India, where label levels have been meaningfully revised every two years for the past decade, resulting in a 35% improvement of the 1 star threshold (the least efficient category) between 2007 and 2018. See Figure 7.

Figure 6: Timeline of Brazilian AC Labeling

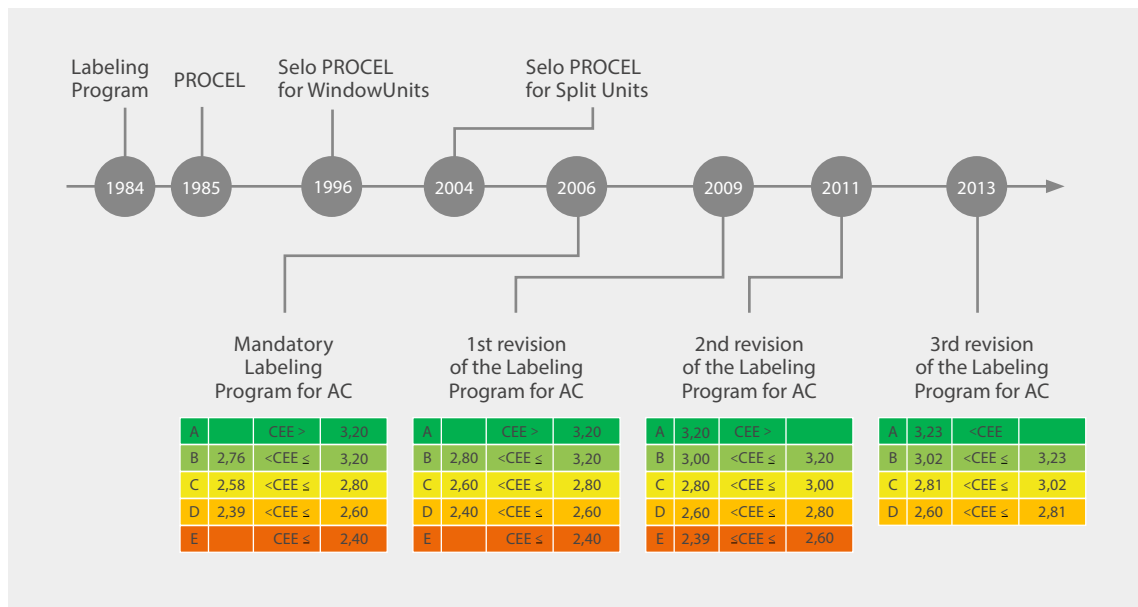
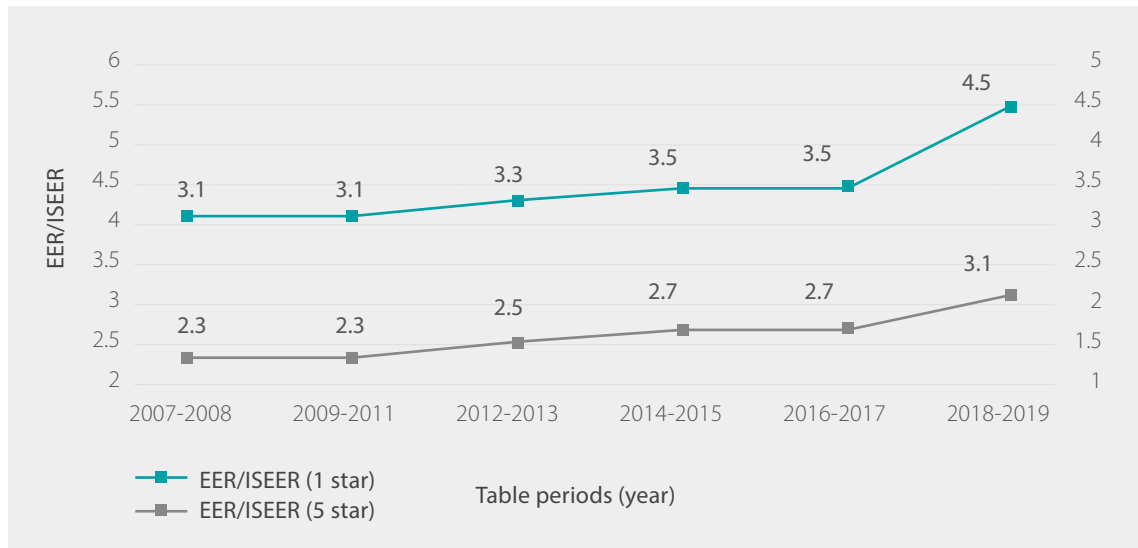


Figure 7: Timeline of Indian AC Labeling



For both the labeling program and the MEPS, the use of the EER metric also limits the ability of policy to push for a shift to high efficiency compressors. The existing standard only requires testing and rating ACs at full speed and does not incorporate performance at part load. The advantages of inverter ACs are not captured in the test metric and therefore are not reflected in inverter ACs more easily meeting the MEPS or being categorized into higher label classes. A shift to a test method and rating that incorporates part-load performance would accelerate the shift towards inverter ACs and stimulate the market for inverter compressors by differentiating these products in the market.

One of the challenges for moving to a test method and metric that captures part-load performance is the lack of testing infrastructure for such a test method. Several AC assemblers noted that there is no laboratory currently operating in Brazil who can perform such a test. Ensuring that local labs are able to test AC units according to the new method may require investments in testing infrastructure as well as training for lab staff.

4.4 Inverter Compressor Compatibility

Another key challenge to improving AC efficiency is ensuring compatibility between inverter compressors and in the rest of the assembled AC units. In order for an inverter compressor to function properly, it is necessary softwares adaptation. This question of compatibility between inverter compressors and the rest of the AC unit is currently a subject of disagreement between Tecumseh and AC assemblers, as the AC assemblers hold that Tecumseh should produce inverter compressors designed for each assembler’s AC units. On the other hand, Tecumseh holds that this is not feasible, as the AC assemblers will not share the specifications of their AC units, and it is impractical to make small numbers of inverter compressors tailored for each AC assembler.

This problem of inverter compressor and assembled unit compatibility is exacerbated by the unusual relationship between AC assemblers and the local compressor manufacturer. Given that this relationship is often acrimonious and mediated by the government, with little direct communication and planning between the two sides, it is difficult for them to cooperate on an efficient solution to this compatibility problem. However, the current tests being performed on Tecumseh compressors by a major AC company may produce a model for moving forward with the production of inverter ACs using locally-manufactured compressors, though this is far from certain.

5. Conclusions and Recommendations

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— 5.1 Conclusions

The Brazilian AC market is large, not integrated with international markets, and still smaller than it was in 2014

With approximately 3.7 million units sold in 2017, Brazil is the fifth largest AC market in the world. However, slow economic growth is expected to prevent the market from returning to its 2014 size of approximately 4.7 million units in the near term. This market size cannot be supplemented with exports since the high cost of production for Brazilian-made ACs renders them uncompetitive in international markets. On the other hand, Brazil's tax and tariff policies prevent significant imports – the country imported less than 100,000 units in 2017, or less than 2% of the total units sold in the country.

The vast majority of ACs sold in Brazil are assembled domestically in Manaus

Multinational AC companies assembling domestically in Manaus include Chinese companies such as Midea and Gree, Korean companies such as LG and Samsung, a European company (Electrolux), and a US company (Whirlpool). Japanese companies such as Fujitsu and Daikin are also present in the market, though with much smaller market shares than the companies mentioned above. In addition, some local companies, such as Elgin, also assemble ACs in Manaus.

The only domestic compressor manufacturer is Tecumseh, who only sells fixed-speed AC compressors

Tecumseh is guaranteed a share of the compressor market through regulation. Besides the current sales of fixed-speed compressors, Tecumseh asserts they could immediately supply 100,000 inverter compressors a year and could increase that number over the coming few years. However, AC assemblers have opted not to purchase the inverter compressors that they offer and instead import all inverter compressors, along with a share of fixed speed compressors, primarily from China and Thailand.

The Basic Production Process (PPB) will continue to require assemblers to purchase a share of their compressors from Tecumseh

The PPB is designed through a complicated process of negotiations between the Ministry of Development, Industry and Trade, AC assemblers, and local AC component manufacturers. A significant share of the Brazilian AC compressor market is reserved for Tecumseh as a result of the PPB design. Tecumseh's high value-added production process and substantial contribution to employment in Sao Carlos in Sao Paulo State match the required goals of PPB design, such as generation of employment, local technological development, and equilibrium between regions of the country. For mini-split ACs and window units, assemblers must purchase 30% and 50% of the compressors from Tecumseh, respectively. The exception to these rules is that manufacturers who only produce inverter mini-splits are not currently required to purchase compressors from Tecumseh, but must dedicate 3% of their revenues to research and development (R&D). The most likely change to the PPB is the removal of the exception for producers of only inverter ACs, particularly if inverters come to dominate the market, as a decrease in Tecumseh's production in Sao Carlos due to loss of market share to imported inverter compressors would contradict the goals of the PPB.

Despite its shortcomings, the AC industry relies on the Manaus Free Zone and the PPB

AC assemblers see the PPB as necessary, although they do not agree with many of its provisions. On one hand, the tax incentives related to the Manaus Free Zone are generally recognized as crucial to the survival of the Brazilian AC industry and it is generally understood that there would be no tax incentives without the PPB, as a domestic supply chain is a key justification for the granting of these incentives. On the other hand, the assemblers would prefer not to buy Tecumseh's compressors, as most of them are large multinationals with well-established international supply chains for compressors, and several of the AC companies also produce compressors overseas. Furthermore, AC producers argue that Tecumseh's compressors are more expensive and lower quality than the compressors available on the international market.

The policy environment is mainly responsible for the barriers to accessing high efficiency compressors in Brazil

The PPB, the tax and tariff framework, and existing energy efficiency policies account for the main barriers to highly efficient inverter compressors in the Brazilian market:

It is not cost-effective to import high efficiency compressors, due to high tariffs and taxes, combined with the regulations surrounding the Manaus Free Zone. The exception to this rule is for assemblers who only produce inverter units and opt to spend 3% of revenue on R&D. These policies are unlikely to change dramatically in the near term as they represent decades of Brazilian industrial policy which has incentivized billions of dollars of investment in the country.

The Brazilian AC market is not large enough to allow for the economies of scale needed to justify large new investments in the production of high efficiency compressors. The impossibility of achieving economies of scale in compressor production in Brazil is largely due to the lack of an export market for ACs.

The lack of ambitious energy efficiency policy - low MEPS levels and infrequent labeling rescaling - has not incentivized AC assemblers to produce more efficient products. AC assemblers and component manufacturers generally agreed that the recent increase in the MEPS level to an energy efficiency ratio (EER) of 3.02 W/W would not lead to any significant changes in the market. Furthermore, the comparative energy label for ACs has not been significantly re-scaled in nearly a decade, leading to little differentiation between highly efficient ACs and less efficient ACs. This lack of differentiation gives manufacturers little incentive to improve the efficiency of their products, as any improvement in efficiency will not be reflected in the label.

The antagonistic relationship that exists between Tecumseh and AC assemblers has made it difficult for them to cooperate on developing AC units that effectively use Tecumseh's inverter compressors. Tecumseh's inverter compressors require software adaptation; however, AC assemblers insist that Tecumseh should design inverter compressors for each assembler's AC units. The lack of dialogue between the AC assemblers and Tecumseh has prevented the two sides from resolving this issue and beginning to produce inverter AC units that use locally-produced compressors.

— 5.2 Recommendations

Some of the barriers to the widespread availability and utilization of high efficiency compressors will prove difficult to address. The system of tax incentives and the PPB is unlikely to be elimina-

ted or dramatically restructured as billions of dollars of investments have been made based on the existing policies. These investments include large industrial facilities that employ thousands of people, and changing the system in a way that would lead to the loss of these jobs at a time when Brazilian unemployment is 13% would be difficult to justify³⁵. It is unlikely that the market for Brazilian-made ACs can grow to justify large investments in new compressor production, as the production in Manaus under this system is not internationally competitive, rendering significant exports unlikely. Furthermore, the Brazilian domestic AC market is unlikely to expand rapidly as Brazil is only just beginning to recover from its recent economic crisis and economic growth is projected to remain under 3% for the foreseeable future³⁶.

Given that the PPB is unlikely to be eliminated and the market is unlikely to grow rapidly, the remaining options for addressing the barriers to high efficiency compressors revolve around energy efficiency policy and more subtle adjustments to the PPB.

Based on all of the key findings noted above, CLASP recommends:

- **More stringent standards.** Further increasing the MEPS of ACs would incentivize the industry to resolve the issues in the compressor market. This could be achieved with minimal disruption by providing a policy roadmap that details planned changes to the MEPS for the coming decade and makes explicit the levels that manufacturers should attain during that period. This policy roadmap should be informed by the market assessment and regulatory impact assessment currently being conducted by the Lawrence Berkley National Laboratory and the Instituto Clima e Sociedade. A timeline of increasing MEPS over the coming decade would give companies a clear signal of the need to invest in efficiency in order to ensure that their products can meet the coming, higher MEPS, and provide them with sufficient notice to work through the challenges in the compressor market. Resolving such barriers might include revisions to the PPB, as discussed below.
- **Updating the test method.** Moving to a MEPS based on a test method and metric that includes part-load performance would capture the benefits of inverter compressors. This would, in turn, incentivize an accelerated shift to using inverter compressors as their efficiency benefits would be reflected in the standard. Inverter ACs would meet the MEPS more easily or populate the high label categories, while fixed speed AC would have more difficulty meeting the MEPS or populate the lower label categories. Moving to such a test method would also require investments in laboratory infrastructure and training, and so we also recommend conducting a study of the existing lab infrastructure and personnel to identify the exact needs to perform such tests.

Notably, several AC companies specifically requested a policy roadmap along the lines of what is described above and noted their support for higher MEPS based on a test method that accounts for the benefits of inverter compressors. In addition, Tecumseh expressed no opposition to substantially higher AC MEPS, as they felt that their compressors would be compatible with more efficient ACs.

- **Label re-scaling.** Re-scaling the Brazilian AC label would also support improvements in efficiency. Ideally, the label would once again have a range from A to D or E, with the A level sufficiently high to only include the most efficient 15%-25% of products on the market. This would

³⁵ Federowski 2018

³⁶ IMF 2018

also give the Selo PROCEL more meaning, as it is currently applied to any product that meets the criteria for an 'A' level classification. In addition, shifting to a test method and metric that accounts for part-load performance would differentiate inverter ACs. The combined effect of these two changes to the labeling system would be an increased incentive for AC manufacturers to invest in producing highly efficient, inverter ACs and to work with the government and the compressor manufacturer to resolve the challenges in the compressor market.

Towards this end, we recommend further analysis of the labeling program, including both INMETRO's comparative label and the Selo PROCEL endorsement label. This analysis would inform a rescaling of the criteria for each label level based on products currently sold in the market.

CLASP has these additional recommendations, but with a lower likelihood of implementation and/or some noteworthy drawbacks:

- **Moving to a more flexible PPB.** Originally, the PPB was based on a points system, wherein purchasing a specific component from a domestic supplier gave the manufacturer a specific number of points toward meeting a minimum number of points required to receive the tax incentives. Such a flexible system allows each manufacturer to choose to meet the PPB in the most efficient way and to avoid purchasing components that would be incompatible with meeting product standards. This could help manufacturers to meet updated efficiency standards even if a specific local component, such as the compressor, is unable to meet the standard, as it provides the flexibility to purchase locally-produced components that best suit their products.
- **Incorporating efficiency into the PPB.** One option would be to include efficiency criteria in the PPB. For example, the PPB could state that only 'A' class equipment can receive tax incentives, while other equipment still must pay taxes. This could be particularly valuable, as manufacturers noted the impossibility of creating further tax incentives for efficient equipment when the tax is already 0%. This would incentivize manufacturers to only or primarily produce or assemble 'A' class equipment and would increase the market price of less efficient equipment. In addition, including such an efficiency criteria in the PPB would support the argument that the PPB serves environmental purposes as described in Article XX of the GATT, increasing the probability of success from a challenge of the Manaus Free Zone and the PPB before a WTO panel. Such a strategy of including efficiency criteria in the PPB would have some major drawbacks. First, it adds yet another economic distortion to the already highly distortionary Manaus Free Zone and PPB system, further separating costs in the free market from the prices that consumers actually pay. Second, such a system would lead manufacturers to strongly oppose any label rescaling as increasing the stringency of the requirements for an 'A' label would reduce the share of their products that is eligible for tax incentives, negatively impacting their bottom line.
- **Directing R&D Spending to Efficiency.** The required R&D spending from manufacturers who only produce inverter units could be a resource for improving efficiency. For example, the PPB could require that manufacturers use this resource to invest in R&D for more efficient products or for the creation of more efficient compressor production lines in Brazil.

The challenge for this approach is that only a handful of manufacturers have opted to move to producing only inverter units, meaning that the pool of R&D funding is relatively small. Manufacturers CLASP interviewed generally believed that the 3% R&D requirement would not provide sufficient funding to develop new products. In addition, this funding would depend on the continued existence of the 3% R&D requirement in the PPB, which would naturally disappear if the MDIC were to approve Tecumseh's request for a requirement to purchase domestically-produced inverter compressors.

— Complete List of Meetings for this Study

AUGUST 6, 2018

Midea/Carrier | Sao Paulo

AUGUST 7, 2018

Samsung | Sao Paulo

Elgin | Sao Paulo

AUGUST 8, 2018

ABRAVA | Sao Paulo

ELETROS | Sao Paulo

AUGUST 9, 2018

Daikin | Sao Paulo

Tecumseh | Sao Carlos, SP State

AUGUST 10, 2018

Ministry of Industry, Development, and Trade (MDIC) | Brasilia

Ministry of Mines and Energy (MME) | Brasilia

AUGUST 11, 2018

Superintendent of the Manaus Free Zone (SUFRAMA) | Manaus

AUGUST 14, 2018

PROCEL | Rio de Janeiro

AUGUST 15, 2018

INMETRO | Rio de Janeiro

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Technical and Economic Feasibility
Study for a High Efficiency
Compressor Market in Brazil

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Instituto Clima e Sociedade

Technical work
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