



CAF DEVELOPMENT BANK
OF LATIN AMERICA
AND THE CARIBBEAN

RESILIENCE WITH EFFICIENCY:

HOW POWERSHARING
CAN CONTRIBUTE TO THE
DECARBONIZATION AND ECONOMIC
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RESILIENCE WITH EFFICIENCY: HOW POWERSHORING CAN CONTRIBUTE TO THE DECARBONIZATION AND ECONOMIC DEVELOPMENT OF LATIN AMERICA AND THE CARIBBEAN¹

Jorge Arbache | Luíz A. Esteves²

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EXECUTIVE SUMMARY

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The central idea behind the notion of Powershoring is that climate change and geopolitical factors have opened a window of opportunity for countries with comparative advantages in the production of clean and renewable energy to attract energy-intensive manufacturing plants in their production processes. Therefore, Powershoring refers to a business strategy of production location, like other locational strategies, such as Offshoring, Reshoring, or Nearshoring. But Powershoring's value proposition is multiple and goes beyond green, safe, cheap, and abundant energy, which are the most immediate factors of business interest in this strategy.

With regard to climate change, extreme events such as heat waves, floods, and droughts have contributed to factory closures and the collapse of strategic global logistics routes. The adverse economic effects of the proliferation of climate events, combined with the shock of the COVID-19 pandemic, have revealed important evidence about the location strategies of many corporations: the risks associated with the geographic concentration of production have been largely underestimated. The Offshoring strategy implied extremely high levels of geographical concentration of production, while also concentrating logistical risks and production interruptions – which, under adverse shocks – produced episodes of widespread shortages of machinery, equipment, parts, pieces, products, and inputs.

Geopolitical factors have contributed to make the energy transition even more challenging. Among these geopolitical factors, the competition between the United States of America (US) and China and the energy crisis in Europe, as a result of the war between the Russians and the Ukrainians, stand out. Some relevant dimensions of this US-China competition include data and cybersecurity, energy and natural resources, and climate change.³ Some of these dimensions are central to the future of energy transition and the global green industry and are especially important for the discussion around Powershoring. European countries, on the other hand, have been the protagonists of the main environmental compliance initiatives. Its decarbonization goals are ambitious and aim to become the first carbon-neutral continent by 2050. However, a set of circumstances has hindered European pretensions to lead the energy transition, including geopolitical factors.

A crucial point to be highlighted concerns the factors that determine the comparative advantages in the



Fatores geopolíticos têm contribuído para tornar a transição energética ainda mais desafiadora

production of clean and renewable energies. The main clean and renewable energies currently available at competitive costs are intermittent and not abundantly and simultaneously available anywhere on the planet. In reality, few locations on the globe are capable of producing all the clean and renewable energies currently available at competitive costs in a simultaneous and complementary way, a fundamental aspect for mitigating the problem of intermittency.

This report seeks to present evidence that LAC has conditions that meet this requirement of simultaneity and complementarity in the production of green and clean energy at competitive costs. Therefore, it presents itself as a favorable environment for attracting investments based on the Powershoring strategy. However, it will not be possible to be exhaustive in this geographic mapping of opportunities in the region. Given the prioritization of the discussion around the different dimensions of the Powershoring topic, it was necessary to select a representative group of economies. In this sense, the cases of Brazil, Chile, Colombia, and Uruguay were selected.

It is necessary to point out that, at this moment, clean and renewable energies already present themselves as highly competitive alternatives to traditional fossil energies, since the operating costs of producing clean and renewable energies have collapsed in the last decade. For example, the Levelized Cost of Energy (LCOE) of solar PV has been reduced by 88% over the period 2010-2021 (US\$0.417/kWh in 2010 and US\$0.048/kWh in 2021). The LCOE for Onshore wind energy was reduced by 68% (US\$ 0.102/kWh in 2010 and US\$ 0.033/kWh in 2021). Finally, the LCOE for Offshore Wind Energy was reduced by 60% (US\$0.188/kWh in 2010 and US\$0.075/kWh in 2021).

Concerning Powershoring's economic value drivers, we can highlight three vectors: (i) the combination of resilience with economic efficiency; (ii) the combination of environmental compliance with economic development; and (iii) the creation of an alternative for the transition and energy security of companies, as well as of different sectors and global value chains, reducing the demand pressure on the electrical systems of countries originating from foreign investments.

Combining resilience with efficiency is already becoming the main driver of industrial location globally and it is expected that this combination will continue to gain importance in the coming years. Resilience, a new element in this agenda, is gaining centrality in the international geography of investments, especially in the corporate strategy of companies with a global presence, which seek productive and market security, in addition to economic efficiency. The comparative advantages reflected in the production costs of clean energies (especially wind and solar photovoltaics) and green hydrogen (H2V) should gain influence in this type of decision-making, especially in those sectors that are intensive in energy consumption in production processes and in those sectors where the demand for decarbonization is pressing. Everything indicates that the deconcentration and diversification of the geography of plants will become critical themes on the investment agenda in the first half of the 21st century.

Another distinctive feature of Powershoring is that it combines environmental compliance with economic development. By making clean energies the gearing of the strategy, Powershoring encourages investments in the climate agenda and accelerates the energy transition and the decarbonization of production at national, regional, and global levels. On the other hand, the attraction of export-oriented manufacturing plants promotes the growth of LAC's GDP, the increase of investment, technology, and innovation, the increase of employment, and the insertion of the region in global value chains. It also promotes small and medium-sized companies, tax collection, local and regional development, and, finally, generalized gains in productivity.

The third vector concerns the fact that LAC's comparative advantages in producing clean and renewable energy - in a challenging geopolitical scenario of energy transition and climate change - provide for the creation of a new class of assets and new opportunities for foreign investment. For example, for the countries of origin of the benefited companies, Powershoring helps to reduce the pressure of demand on the electrical systems, which improves the conditions and planning of the energy transition, serving as an engine of business competitiveness, creating environmental compliance alternatives for



Combining resilience with efficiency is already becoming the main driver of industrial location globally and it is expected that this combination will continue to gain importance in the coming years

companies under pressure and making it possible to import goods at relatively lower prices and with a low carbon footprint. In other words, Powershoring contributes to environmental commitments and protects companies' and people's interests.

Powershoring can be classified as an industrial policy, as it promotes manufacturing and the transformation of the productive structure. However, unlike other industrial policies previously implemented in the region, it is a policy that has clean energy, foreign direct investment, exports, technology, and innovation as its central points, and its progress does not necessarily depend on tax incentives, subsidies, protectionism, or discrimination. On the contrary, the fulcrum of the strategy is in the comparative advantages, in the natural resources, and in the climate change. It is, therefore, an innovative proposal for industrial policy, in which climate change and the strengthening of markets are its starting points.

On the other hand, the success of Powershoring as a policy to promote and transform the productive structure of LAC faces some risks and threats, which can be divided into two groups: external and internal. The risks and threats of an external nature are mostly related to the effects and impacts resulting from the Reshoring strategy anchored in generous subsidies for the domestic production of clean and renewable energy in developed countries. The risks and threats of an internal nature are related to how some political and business leaders in LAC envisage exploiting the opportunities arising from the region's comparative advantages in the production of clean and renewable energies.

In terms of external threats and risks, the effort of developed economies to make Reshoring a hegemonic locational strategy stands out, with the concentration of industrial production in the US and Europe. A big step in this direction was the approval of the Inflation Reduction Act of 2022 (IRA) in the US. This is a US\$ 433 billion stimulus package, of which US\$ 369 billion is earmarked for energy security and climate change programs. The IRA provides subsidies in the form of tax credits and conditions these credits on US-based production and input supplies from North America and has been interpreted by analysts, policymakers, and academics as a potential violation of international trade rules. There seems to be a consensus outside the US that the IRA has the potential to erode the multilateral system of cooperation, including serving as a trigger for a "transatlantic race" of subsidies between the US and Europe.

However, the challenges of the energy transition and the global decarbonization goals make Reshoring's hegemony in the US and Europe a non-trivial task for at least two reasons. The first one is the very risk of geographic concentration of industrial production, a factor that has motivated a reassessment of the pertinence of locational strategies of the "winner takes all" type. The second one concerns the absence of relevant comparative advantages in the joint and complementary production of different clean and renewable energies by those economies. There is no doubt that the US and Europe have a unique and extremely valuable and sophisticated set of tangible strategic assets (physical infrastructure, natural resources, and geographic location) and intangibles (sophisticated institutions and markets, and human and intellectual capital). However, the production of clean and renewable energy is not one of them, at least in the short and medium term.

Additionally, there is no consensus in the specialized literature that tariff, and non-tariff barriers, subsidies, and fiscal incentives can compensate for comparative disadvantages in the long term on a permanent basis. Therefore, the risks associated with the effects of the IRA and similar programs should not be overlooked by the LAC, in the same way, that its benefits and incentives should not be overestimated by taxpayers, companies, and private investors.

In terms of internal threats and risks, one should point out the way in which some political and business leaders in LAC envisage exploiting such opportunities arising from the region's comparative advantages in the production of clean and renewable energies. There is a strong movement toward the constitution of a kind of a "primary-export model" of green energy, with emphasis on the export of H2V transported in the form of ammonia. The strategy of establishing H2V or green ammonia export hubs

in the Southern Hemisphere, with emphasis on LAC and the African continent, is more in line with the European energy transition agenda, such as the EU Green Deal and the EU Hydrogen Strategy than with the strategies of exporting countries for their energy and value creation transitions.

Partnerships involving Europe and LAC to develop the production and commercialization of H2V, and green ammonia can be mutually advantageous and beneficial. In the same way that the creation of hubs for the export of H2V or green ammonia in the LAC region does not represent a problem, as long as other equally important opportunities for the generation of wealth and economic value are not neglected due to a primary-export development strategy.

Another point to be highlighted regarding Powershoring concerns its business value proposition. LAC's comparative advantages in producing clean and renewable energy, with energy security at competitive costs, in a challenging international scenario of energy transition and climate change, have led to the creation of a new class of assets and opportunities for private investment.

The fact is that the decarbonization targets imposed on economies around the globe imply the emergence of an energy transition. The emergency affects everyone, but the levels of urgency vary from country-to-country and from sector-to-sector, depending on several factors, including the structures of the energy matrices and profiles of installed capacity and electricity generation, in addition to the different exposures to risks from climate events and geopolitical risks. From this perspective, it seems clear that the Powershoring strategy constitutes a unique opportunity for those investment projects in which the costs incurred in delaying the energy transition are increasing and disproportionately high.

In addition to producing economic value for private investors through risk diversification and greater resilience, the Powershoring strategy is aligned and in compliance with the environmental, social, and corporate governance (ESG) agendas and the Sustainable Development Goals (SDGs). This means that Powershoring is a strategy that is highly adherent to the objectives of companies that pursue the triple bottom line concept, or tripod of sustainability, a business concept that postulates that companies must commit to measuring their social and environmental impact in addition to financial performance, instead of just focusing on profit generation or the standard "bottom line".

Critics of the triple bottom line model often dismiss sustainability as a fringe issue, a passing trend, greenwashing, or an unimportant business issue.

However, the fact is that these kinds of criticisms are well over a decade old and there is no evidence that we are dealing with a passing trend. Quite the opposite. Governments, consumers, regulators, investors, shareholders, banking institutions, insurers, reinsurers, and rating agencies have increasingly pressured companies to pursue these triple bottom-line objectives.

The Powershoring strategy is in line with new proposals for generating economic value for organizations, such as the Shared Value Creation models and the Circular Economy Model. The central point is that the business models that constitute the Powershoring strategy (production, distribution, and commercialization of clean and renewable energies) were originally conceived in the light of this new paradigm of “stakeholder capitalism” - as opposed to the previous paradigm of “shareholder capitalism”, even in a period of history when it was believed that such business models would not be economically viable, sustainable, replicable and scalable.

Adoption of Powershoring in LAC should consider the “Three-Way Strategy.” The first way consists of promoting the enabling factors for increasing the production of green, safe, cheap, and abundant energy. The second way consists of promoting the expansion of H2V production to levels that would guarantee scale gains, scope gains, and price reduction, to face US and European subsidies, in addition to learning gains, knowledge of the business model, training of national and international partnerships and local production of equipment, in such a way as to convert the region into a great global H2V hub, taking advantage of the comparative advantages of green energy, industrial land, water, and favorable geographical position. The third way consists of the priority use of this gas for the promotion of Powershoring, and exporting the surplus.

Such strategies are complementary, although they are not temporally synchronized. This is because we are still far from achieving safe and economically viable technologies for the maritime transport of

H2V in the form of ammonia, as well as equally safe and economical technologies for converting green ammonia into H2V for industrial use in the ports of importing countries.

The report also lists a non-exhaustive list of public policies that adhere to the Three-Way Strategy. Additionally, it highlights how the Multilateral Development Banks (MDBs) can contribute to Powershoring through five support vectors. The first, promoting and disseminating studies, surveys, technical reports, and economic-financial feasibility studies, including on the viability of green energy plants, and regulatory and institutional development of the Powershoring agenda. The second is through the organization of technical events on Powershoring. The third, supporting public policies aimed at Powershoring. The fourth, supporting the articulation of stakeholders on the agenda. The fifth, with credit, support in issuing bonds, guarantees, and other financing instruments for green energy plants and the necessary infrastructure for Powershoring.

Powershoring is a unique opportunity to convert the region’s comparative advantage in green energy, distancing from the international geopolitical agenda, and the ability to address the combination of resilience and efficiency into potent instruments for promoting economic and social development. Powershoring will have important effects on productivity, competitiveness, technology, and innovation, and will contribute to the formation and consolidation of national and regional value chains. Powershoring will certainly be beneficial for the region, but it will be even more useful for companies that understand the virtues of this strategy.

The next steps in this work agenda include estimates of the potential for foreign direct investment and exports associated with Powershoring, study for selected countries of the sectors potentially most interested in Powershoring in LAC using indicators of energy intensity, environmental commitments, among others, and case studies of companies and sectors that are already benefiting from the strategy’s value propositions in the region.



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INTRODUCTION

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The term Powershoring was originally addressed in two opinion articles by Jorge Arbache (2022a⁴ e 2022b⁵). The central idea is that climate change and geopolitical factors have opened a window of opportunity for countries with comparative advantages in the production of clean and renewable energy to attract manufacturing plants that are intensive in energy consumption in their production processes and committed to decarbonization. Powershoring therefore refers to a business strategy for the location of production, like other locational strategies, such as Offshoring, Reshoring, or Nearshoring. But Powershoring's value proposition is multiple and goes beyond green, safe, cheap, and abundant energy, which are the most immediate factors of business interest in this strategy.

The first proposal is associated with the commitments signed by the Paris Agreement, which seeks to combat the effects of climate change and the reduction of greenhouse gas emissions⁶. The practical implication was the establishment of ambitious targets for the decarbonization of economies and major compliance challenges for companies. However, there is not just a compliance challenge here. Carbonization generates negative externalities that, currently, already have organized markets to price them through compensatory credits, which give their holders the right to pollute. The problem is that, depending on the prospective scenario for such markets, the price of carbon offsetting could grow considerably in the coming years. So, the problem of decarbonization targets is twofold: environmental compliance and the management of environmental risks and liabilities.

Still, regarding risk management, experience shows that the adverse economic effects of the COVID-19 pandemic, the increase in extreme climate events, and geopolitical events have revealed that the risks associated with the geographical concentration of production due to strategies such as Offshoring

practiced by multinational companies for decades have been underappreciated at best. The Offshoring strategy implied, on the one hand, high productivity gains resulting from economies of scale and scope. On the other hand, the concentration of production in a few Offshoring destination countries increased the logistical risks and production interruptions, resulting in non-isolated episodes of widespread shortages of machinery, equipment, parts, pieces, products, and inputs and even permanent losses or quasi-permanent losses in market share.

Regarding the cost driver, two points are worth mentioning. The first one is that the Offshoring strategy, which is focused on minimizing costs, especially labor, valued the comparative advantages of countries like China and others in Asia. This order would expand giving rise to a growing economic, commercial, and investment interdependence, the benefits of which would be shared by many people around the world in the form of consumer goods at low prices. However, real wages in some of those countries have been persistently rising.

The second point is that the Powershoring strategy has benefited from the emergence of climate change and the reduction of operating costs of producing clean and renewable energy. For example, according to IRENA (2022), the Levelized Cost of Energy (LCOE) of solar PV has been reduced by 88% over the period 2010-2021 (US\$0.417/kWh in 2010 and US\$0.048/kWh in 2021). The LCOE for Onshore wind energy was reduced by 68% (US\$ 0.102/kWh in 2010 and US\$ 0.033/kWh in 2021). Finally, the LCOE for Offshore Wind Energy was reduced by 60% (US\$0.188/kWh in 2010 and US\$0.075/kWh in 2021). The fact is that, at this moment, clean and renewable energies are already presenting themselves as competitive alternatives to traditional fossil energies and it is likely that this competitiveness will continue to grow.

This report shows that the combination of resilience

⁴ "Powershoring". CAF, Development Bank of Latin America. See: <https://www.caf.com/pt/conhecimento/visoes/2022/11/powershoring/>; Valor Econômico. See: <https://valor.globo.com/opiniao/coluna/powershoring.ghtml>

⁵ Arbache, Jorge (2022a). "Powershoring II". CAF, Development Bank of Latin America. See: <https://www.caf.com/pt/conhecimento/visoes/2022/12/powershoring-ii/>; Valor Econômico. See: <https://valor.globo.com/opiniao/coluna/powershoring-ii.ghtml>

⁶ The "greenhouse effect" is a natural phenomenon responsible for maintaining average global temperatures. However, with excess gas emissions, more heat is retained in the atmosphere, resulting in increased global average temperatures.

and efficiency is already becoming the main driver of industrial localization on a global level. Resilience is a new element in this agenda and is gaining centrality in the international geography of investments and, in particular, in the corporate strategies of companies with a global presence that seek productive and market security, in addition to efficiency. The comparative advantages reflected in the production costs of green energy should gain influence in decision-making, with emphasis on energy-intensive sectors that most need to decarbonize. Everything indicates that the deconcentration and diversification of the geography of plants will become critical themes on the investment agenda in the first half of the 21st century.

The report provides a set of information and evidence that countries in the LAC region enjoy broad comparative advantages to benefit from the Powershoring strategy as providers of clean and renewable energy, in safe, economical, and non-intermittent systems. On the demand side, the report discusses the characteristics of investment projects and regions with greater potential for participation in the Powershoring strategy. The document also addresses the risks to the strategy from a LAC perspective.

Powershoring has a distinctive and fundamental characteristic: it combines environmental compliance with economic development. By making clean energies the gearing of the strategy, Powershoring encourages investments in the climate agenda and accelerates the energy transition and the decarbonization of production at a national, regional, and global levels. On the other hand, the attraction of export-oriented manufacturing plants promotes the growth of LAC's GDP, the increase of investment, technology, and innovation, the increase of employment, the reduction of poverty and income inequality, and the insertion of the region in global value chains. It also promotes small and medium-sized companies, tax collection, local and regional development, and, finally, generalized gains in productivity. For the countries of origin of the benefited companies, Powershoring helps to reduce the demand pressure on the electrical systems, which improves the conditions and the planning of the energy transition, works as an engine of business competitiveness, creates alternatives for environmental compliance for companies under pressure and makes it possible to import goods at relatively lower prices and with a low carbon footprint. In other words, Powershoring contributes to environmental



Powershoring encourages investments in the climate agenda and accelerates the energy transition and the decarbonization of production at a national, regional, and global levels.

and social commitments and protects companies' and people's interests. In summary, the strategy has a high potential for promoting sustainable, sustained, and inclusive growth.

The report is divided into ten sections, including this introduction. The second section addresses the economic rationale underlying the Powershoring strategy. The third section provides answers to the question "which countries and regions enjoy the most comparative advantages in the production of clean and renewable energy?". The fourth section provides answers to the question "which investment projects would enjoy more competitive advantages when exploring the Powershoring strategy?".

The fifth section assesses the risks to the Powershoring strategy in LAC. The sixth section assesses the drivers of Powershoring's enterprise value proposition. The seventh section explores the potential of Powershoring in terms of achieving widespread productivity gains arising from greater economic complexity and agglomeration economies. The eighth section examines the public policy and enabling factors of the Powershoring strategy. The ninth section examines the role of multilateral development banks in Powershoring. Finally, the last section presents the conclusions and final considerations.



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POWERSHORING: WHAT IS IT?



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The first step towards elucidating the location strategy based on Powershoring involves understanding some of the determinants of business decisions regarding the location and geographic allocation of production plants.

The economic theory manuals point to the search for the maximization of the firm's profit as the main driver of the business' economic decision. Theoretically, economic profit corresponds to the excess of the selling price of the good over its marginal cost of production. However, in this report, we work with the notion of business objective based on the generation of economic value added (EVA)⁷, which corresponds to the excess of net operating profit after taxes over the cost of capital invested in the business project. This value metric is commonly used in investment analysis and asset valuation techniques (Valuation), as it reveals the contribution of different value drivers of firms (Neto, 2017)⁸.

Different locations of industrial plants tend to produce different revenue structures, operating costs and expenses (production, logistics, marketing, among others), financial income and expenses, and different exposures to risks. Therefore, we can expect that the same production plant configuration will present different results for the generation of EVA, depending on where they are located.

We will show that the location strategy of firms has undergone major changes over the last few decades, mainly from the second half of the twentieth century. Such changes unfolded in the form of waves driven by structural economic, technological, and geopolitical changes. There are reasons to believe that a new wave is in the making, driven by the current geopolitical configuration, characterized by the rivalry of the two largest economies in the world, the US and China, by the impacts resulting from the commitments around the climate transition, with carbon neutrality targets, and

by the increased incidence of extreme natural events.

The effects of the COVID-19 pandemic contributed to accelerate the formation of this new firm location strategy, since strategies based on cost minimization resulted in high levels of geographic concentration of production, while also increasing logistical risks and production interruptions, implying risks of a general shortage of supply of machinery, equipment, parts, pieces, products, and inputs.

In this sense, large economic groups have begun to review their localization strategies, bringing the topic to the list of strategic priorities. This movement is largely justified, also because the perception has grown that the reversal of the geographic concentration of production and its respective risks does not necessarily imply a loss of competitive advantages in costs (CBRE, 2020)⁹.

The possibility of reducing risks, without necessarily incurring additional total costs (operating and financial), may seem "too good to be true", since it involves an economic decision without tradeoffs, that is, a real "free lunch". However, this possibility should not be interpreted in this way, at least not in this specific situation. This possibility exactly reflects the pillar of Modern Portfolio Theory (TMP),¹⁰ which shows that risk diversification in portfolios is perhaps the only "free lunch" that economic reality can provide¹¹.

As it will be seen in greater detail, it was not just sanitary measures as a result of the COVID-19 pandemic that closed factories and collapsed strategic global logistics routes. Climate events, such as extreme heat waves and floods, have also contributed to the suspension of production and even the closure of factories. Geopolitical conflicts such as wars and terrorist attacks have also contributed to the intermittency of production and the suspension of the provision of logistical and other services aimed at production and distribution.

⁷ The disaggregated components of EVA include (i) operating revenues, (ii) operating costs and expenses, (iii) taxes, (iv) the cost of raising third-party funds and (v) the opportunity cost of shareholders' capital which, in turn, is computed from different forms of risk exposure (sectoral risk, financial leverage risk, non-diversifiable risk, real interest rates, inflation and country risk).

⁸ Neto, Alexandre Assaf (2017). Valuation: Métricas de Valor & Avaliação de Empresas. 1st ed. Editora Atlas e Instituto Assaf: São Paulo/SP.

⁹ CBRE (2020). "Location Strategies: COVID-19 and beyond". CBRE. See: https://f.tlcollect.com/fr2/720/84333/Global_Location_Strategies_post-C19_Final.pdf

¹⁰ Markowitz (1952). "Portfolio Selection". The Journal of Finance, Vol. 7 (1): pp. 77-91.

¹¹ Here we are referring to a portfolio of assets made up of productive plants, in which each plant represents a cash-generating unit.

The adverse economic effects of the pandemic and climate and geopolitical events have revealed important evidence about location strategies: the risks associated with the geographic concentration of production were underestimated (at best), even with the technical support of financial institutions, investors institutions, large consulting firms, and insurance and reinsurance companies. If, on the one hand, risk diversification is a “free lunch”, the same cannot be said about risk management failures.



We hope that by now it is clear to the reader why we believe that a new wave of localization strategy is brewing.

We hope that by now it is clear to the reader why we believe that a new wave of localization strategy is brewing. However, before moving forward in the discussion about the characteristics of a new wave, it is necessary to present a brief discussion about the history of the already constituted waves of localization strategies. A taxonomy in this sense was developed by CBRE (2020). In this document, five waves are reported, divided into two major drivers.

The first wave is called the Onshoring strategy, which aims to concentrate production in a single location, thus seeking to obtain economies of scale that imply a significant reduction in production operating costs. The second wave is called the Nearshoring strategy, which aims to relocate part of the operations to a region geographically close to that initially established by the Onshoring strategy. Its objective is to maintain low production costs (commonly labor), while providing geographic risk diversification. The third wave concerns the Offshoring strategy, characterized by the reallocation of production to locations with the lowest overall production costs (emphasis, again, on labor), regardless of geographical proximity to the locations that originated and hosted the corporations. This is the case of a cost-minimizing strategy involving corporations with a global footprint. These three waves constitute strategies based on the minimum cost driver.

The fourth wave is characterized by the Offshore-to-Onshore movement, just as the fifth wave is characterized by the Offshore-to-Nearshore movement. In both strategies, the value driver is the focus on the customer. Costs are increased, but the focus of profitability becomes obtaining incremental revenues resulting from the differentiation of services provided, with emphasis on issues involving communication with customers and delivery. But there are still political factors involved. This is because the industry's move to Asia has not been painless. The economic stagnation

of former industrial regions in the US and Europe led to the emergence of controversies about the benefits of globalization, which reverberated in organized anti-globalization political movements, which culminated in events of great proportions, such as Brexit¹². The crisis in the supply of medicines and other imported inputs in China and the collapse of logistics during the pandemic would provide even more ammunition for critics of globalization. It was in this environment, watered by the growing geopolitical dispute between the US and China, that the concepts of Nearshoring and Reshoring were forged, which preach the supposed virtues of bringing back home the North American and European industrial plants operating in Asia.

The CBRE study also suggests the possibility of the formation of a sixth wave, characterized by Endshoring, and a seventh wave, characterized by Rightshoring. The sixth wave is intrinsically related to issues involving security in the supply of machines, equipment, parts, pieces, products, and inputs. The motivation behind this movement stems from the traumatic experiences provided by the adverse effects of the COVID-19 pandemic. Finally, the seventh wave, Rightshoring, involves the best combination of cost and efficiency, highlighting the location strategy based on the local availability of professionals in the STEM areas (Science, Technology, Engineering & Mathematics), as well as talents in the areas of Data Science and Artificial Intelligence.

A point to be highlighted is that the increasing automation of productive operations has reduced the need for large contingents of “blue collar” workers, in the same way, that the increasing use of data science and artificial intelligence has reduced the need for large contingents of “white collar” workers, including professionals in the STEM areas, among others. On the other hand, one aspect deserves to be highlighted in this discussion: industrial automation, the training of artificial intelligence models (machine learning and deep learning), and data mining consume and will continue to consume increasing amounts, and by no means negligible, of energy (this topic will be discussed later).

This report proposes the addition of a new localization strategy to the aforementioned taxonomy. This is the Powershoring strategy, which seeks to provide the greatest potential value of EVA through access to clean, renewable, safe, economically viable, and competitive energy.

However, the economic calculation for determining the best geographic location of productive plants today is more complex than that used in the past. In the vast majority of situations, a competitive advantage in one dimension can be fully or partially offset by a competitive disadvantage in another dimension. For example, locations that have competitive advantages in operating costs (with labor and logistics, for example), under situations of stability, can become economically unfeasible with the mere expectation of instabilities and conflicts. In this hypothetical situation, the low resilience to shocks and events increases the risk premium of the projects, also increasing their capital costs, whose negative impact can offset the gains resulting from the initial advantages, till then achieved through operating cost savings.

The idea of a production plant being located where energy is available is not new. In reality, the fact is that the manufacturing industry was originally conceived to be physically connected to its energy source. Until the mid-nineteenth century, the spatial segmentation of energy production and the production of goods was not technologically feasible. With the development of electricity generation, transmission, and distribution technologies, this locational rigidity was broken, as highlighted by PINTO JÚNIOR (2007)¹³:

“Electricity, thanks to its great transmissibility (displacement in space without loss) and flexibility (simple and efficient conversion into heat, work, and lighting), freed machines and tools from the restriction of location, making energy omnipresent and placing it at the everyone's reach” (Pinto Júnior, 2007 p. 152).

Another important step in this direction (the ubiquity of energy) was the development of technologies for extracting, producing, refining, and transporting fossil fuels. In fact, oil originated the most competitive energy industry and founded the techno-energetic base of the development of the 20th century (Pinto Júnior, 2007).

On the other hand, such economic progress did not advance without the occurrence of equally impactful and deleterious adverse effects. The first of these was the advent and protagonism of energy geopolitics from the second half of the 20th century onwards. The vast majority of diplomatic and armed conflicts of the period (including wars, invasions, revolutions, and terrorist attacks) have some degree of relationship with the geopolitics of energy, including issues related to oil and nuclear energy. The second effect is related to environmental issues, more specifically to the massive emissions of carbon dioxide (CO2) provided by the burning of fossil fuels and its adverse impact on the Ozonosphere (or ozone layer), known as the “greenhouse effect”.

Based on the points developed in the previous paragraphs, some questions are addressed in this report:

- Why should we believe in a new protagonism of the location of energy resource sources for optimal allocation decisions of productive plants around the world?
- The rigidity that in the past spatially united machines and tools with the available energy sources constituted an obstacle to productivity gains and value creation. Should we expect anything different from the Powershoring strategy?
- Which countries and regions enjoy the most comparative advantages in producing clean and renewable energy?
- Which investment projects would enjoy more competitive advantages when exploring the Powershoring strategy?

¹² A detailed discussion of different economic groups' frustration with the effects of globalization can be found at: Stiglitz, Joseph (2002). Globalization and Its Discontents. W. W. Norton & Company: New York

¹³ Pinto Júnior, Helder (2007). Economia da Energia. 1st Ed. Campus Elsevier: São Paulo.

A provisional answer to the first two questions is that this time, the nature of this union has a different character for at least two reasons. The first is of a geopolitical and geoeconomic nature and the second reason is of a technological nature. First, recent geopolitical and geoeconomic factors have threatened and, in some situations, even compromised the distribution logistics of traditional energies (fossil fuels), thus reducing the energy security of important economies around the world, resulting in cost inflation and risks increasing associated with the discontinuity of residential and industrial energy supply. Secondly, although clean and renewable energies still face logistical and intermittency challenges – which implies a kind of “return to the past”, where the locational rigidity of productive plants due to energy issues was the rule – their costs are declining and, at this moment, they already present themselves as highly competitive alternatives to traditional “ubiquitous” energies.

However, even considering the substantial reductions in the leveled costs of wind and solar photovoltaic energy in the last decade, as seen above, some challenges for the completeness of the energy transition are still posed for such technologies. The first is related to its intermittent nature, that is, solar energy, for example, is only produced when there is exposure to the sun. In the same way, wind energy production requires wind.

The second challenge is logistical. Clean and renewable sources, such as solar and wind energy, already have “prototyping of storage technologies”, that is, such energies have been used to produce H2V. However, the logistics of transporting the H2V is still a major technological challenge. Likewise, even though the conversion of solar and wind energy into electricity is relatively simple, its transmission over long distances requires investments in infrastructure for transmission systems, distribution, stations, and substations.

Therefore, this set of obstacles implies a lack of complementarity between the capacity to produce and the capacity to transport clean and renewable energy. Resources for production are abundant (in some places more than others) and technological advances and economies of scale have reduced its capital requirements and incremental costs. However, the same facilities found in production are not found in the transport and transmission of such energies.

The question of the intermittency of these clean and renewable energies increases the complexity of the problem and the challenges for the completeness of the energy transition. In these cases, the energy security of the system requires back-up capacity (dispatchable energy capacity), preferably by other clean and renewable energies, and/or storage solutions.

Nuclear energy, for example, has been considered a candidate in these cases, as it is clean energy (it does not emit greenhouse gases). However, it is exhaustible and non-renewable, in addition to its production facing increasing restrictions, especially after the accident involving the Fukushima I Nuclear Power Plant (Japan), in March 2011. Electric energy is also a potential candidate (being clean and renewable), but it requires huge investments in the expansion of transmission lines and a change in the way electricity markets are organized (Guimarães, 2021). Natural gas, in turn, can serve as a transitional fuel in this task. Although it is considered the cleanest among the energies derived from fossil fuels, it must be recognized that it has an important role to play for several countries in LAC. It is also important to recognize the controversy in Europe and other parts of the world regarding its contribution and use in the challenge of decarbonization.

This means that guaranteeing energy security in a system based exclusively on clean and renewable energies is a major challenge in the short and medium term, probably not readily achievable for the vast majority of countries and regions. Likewise, the technological challenge of operating a completely decarbonized industrial plant, with the proper energy security, is not one of the most trivial. This requirement involves the need for this industrial plant to be located in a geographic space where different clean and renewable energies can be readily available in a complementary regime, at competitive prices.

This set of challenges and complexities opens a window of opportunity for some economies around the world and, in particular, for LAC. Throughout this report, we examine selected countries in the region that have great potential to face such challenges, in addition to serving as a benchmark for initiatives, institutional arrangements, and the formulation of public policies for other countries in the region.



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POWERSHORING: BY WHOM?



Photo: Adobe Stock

ENERGY SECURITY WITH CLEAN AND RENEWABLE SOURCES

As already mentioned, the purpose of this report is to present the concept of Powershoring and evidence that LAC has economies that provide favorable environments for attracting investments based on this strategy. However, it is not possible to be exhaustive in this text. We have selected a group of representative economies that reflect the heterogeneity of the Region¹⁴. We examined the cases of Brazil, Chile, Colombia, and Uruguay.¹⁵

To begin the analysis of the potential of these economies for Powershoring, the first step was to assess the current composition of the respective energy matrices.

Figure 1 presents a table with the matrices of each of the selected countries, as well as the world matrix, serving here as a comparison parameter.

FIGURE 1. ENERGY MATRICES – SELECTED COUNTRIES 2020

Energy Matrix - Selected Countries, 2020									
Energy Sources	Brazil		Chile		Colombia		Uruguay		World
	TJ	%	TJ	%	TJ	%	TJ	%	%
Mineral Coal	587272	5%	281610	18%	185331	11%	159	0%	27%
Natural gas	1258436	11%	202028	13%	438213	26%	2504	1%	23%
Nuclear	153301	1%	0	0%	0	0%	0	0%	5%
Hydro	1426778	12%	78743	5%	179918	11%	14738	7%	3%
Biofuels and Biomass	4044054	34%	330666	21%	227599	14%	93709	43%	43%
Oil	4134734	35%	636247	40%	642154	38%	87756	40%	32%
Solar, Wind etc.	28818	72%	59560	4%	759	0%	21375	10%	0%
Total	11892762	100%	1588854	100%	1673974	100%	220241	100%	100%
HHI Concentration	0,27		0,26		0,26		0,35		0,24
Fossil Energy Contribution (%)	50,3%		70,5%		75,6%		41,1%		82,0%

Source: International Energy Agency, [iea.org: https://www.iea.org/countries](https://www.iea.org/countries)

¹⁴ Nor will it be possible to exhaust the discussion around the potential of Powershoring in these countries. Some of them have continental dimensions and there is great heterogeneity between their own internal regions and states, including in terms of clean and renewable energy potential.

¹⁵ In the second phase of this document, we will study another set of economies in the region.

Quantities for each of the sources that make up the matrices are specified in Terajoules (TJ). The composition of the matrices includes mineral coal, natural gas, nuclear energy, hydroelectric energy, biofuels and biomass, oil, and the group of other sources, which includes clean and renewable energies, such as solar photovoltaic and wind energy. Additionally, the contributions of each of these sources in the constitution of the matrices are specified in percentage terms. In the case of the world matrix, which will serve for comparative purposes, we are only interested in its composition with the percentage contributions of each of the energy sources.

The first point to be highlighted is that all selected LAC countries have percentages of mineral coal use lower than the world matrix. Coal corresponds to 27% of the composition of the world matrix. The selected country with the highest percentage of this source is Chile, with 18%. The positive highlight is the case of Uruguay, whose energy matrix is completely free of mineral coal.

Regarding natural gas, Colombia has a contribution of 26%, slightly higher than the contribution of natural gas in the world matrix, which is 23%. The other selected countries are less intensive in the use of natural gas, highlighting, again, the case of Uruguay, where the contribution of natural gas to the composition of the matrix is only 1%.

Concerning nuclear energy, only Brazil contributes to its matrix, with 1%. The contribution of nuclear energy to the world matrix is 5%. However, it should be noted that the production and consumption of nuclear energy is highly concentrated in a very small number of countries.

The potential for hydroelectric power generation in the region is reflected in the fact that all selected economies have contributions higher than the global matrix, which is only 3%. In the cases of Brazil and Colombia, such contributions reach 12% and 11%, respectively. A similar result is identified in the case of biofuels and biomass. All selected economies present contributions above the world parameter of 10%. In this case, the highlights are Uruguay and Brazil, whose shares are 43% and 34%, respectively. In the case of Oil, all selected economies also have shares above the global comparative parameter of 32%. In the cases of Chile and Uruguay, this percentage reaches 40%.

Finally, with regard to other clean and renewable energies, such as solar and wind energy, it can be seen that the results in 2020 were still incipient around the

world. In the case of the world matrix, the contribution of these energies was irrelevant (close to 0%). In the cases of Uruguay and Chile, contributions were already highlighted, with shares of 10% and 4%, respectively.

A second measure to evaluate the composition of energy matrices is the Herfindahl–Hirschman concentration index (HHI). The index varies between zero and one, where the closer to the unit, the greater the degree of concentration. For example, a matrix with a single type of energy source (concentrating 100% share) would have an HHI equal to unity. The HHI of a widely diversified matrix would tend to the value of zero.

It can be seen that the matrices of all selected countries in the region have higher concentration levels than the world matrix (HHI = 0.24). In most cases, the differential is small, suggesting that the degrees of concentration are not very different from the world level, with the exception of the case of Uruguay, where the concentration index is 0.35¹⁶.

Finally, we evaluated one last indicator: the contribution of the sum of energies from fossil sources for each of the matrices. In the case of the world matrix, this percentage is 82%. This measure is lower for all selected countries, with emphasis on Uruguay and Brazil, with percentages of 41.1% and 50.3%, respectively. This indicator can provide some insight into the dimension of the challenge imposed on each country in terms of decarbonizing their energy matrices.

Therefore, based on the data reported in the table in Figure 1, we can conclude that the selected countries have degrees of energy diversification similar to those of the world matrix, however, they have matrices with much higher levels of decarbonization. In the case of Uruguay, the degree of diversification of energy sources is lower. However, 60% of its energy matrix consists of clean and renewable energy sources.

The data from the energy matrices are analytically important, but they do not reflect, in isolation, the energy transition potential and effort of each country. Information related to installed capacities and electricity generation (by primary sources) can contribute to adding more analytical elements in this sense. Thus, from now on, data on installed capacity and energy generation for 2021 for each of the selected countries is analyzed.

Figure 2 presents data relating to installed capacity information in MW (Megawatt) by primary source of energy in each of the selected countries.

FIGURE 2. INSTALLED CAPACITY (MW) – SELECTED COUNTRIES 2021

Capacidade Instalada (MW) - Países Selecionados 2021Fontes								
Sources	Brazil		Chile		Colombia		Uruguay	
	MW	%	MW	%	MW	%	MW	%
Biofuels and Biomass	15616	8,1%	414	1,4%	200	1,1%	425	8,5%
Mineral Coal	3453	1,8%	5062	17,2%	1658	9,2%	0	0,0%
Wind	18877	9,8%	3184	10,8%	20	0,1%	1518	30,4%
Natural Gas	16977	8,8%	4348	14,7%	2684	14,9%	3	0,1%
Geothermal	0	0,0%	45	0,2%	0	0,0%	0	0,0%
Big Hydro	103001	53,5%	5653	19,2%	10976	61,1%	1538	30,8%
Small Hydro	6351	3,3%	1185	4,0%	970	5,4%	0	0,0%
Nuclear	1990	1,0%	0	0,0%	0	0,0%	0	0,0%
Other fossils	166	0,1%	0	0,0%	0	0,0%	890	17,8%
Oil and Diesel	9047	4,7%	4257	14,4%	1119	6,2%	297	5,9%
Solar Fotovotaica	17188	8,9%	5242	17,8%	333	1,9%	324	6,5%
Solar Thermal	0	0,0%	110	0,4%	0	0,0%	0	0,0%
Total	192667	100,00%	29500	100,00%	17959	100,00%	4994	100,00%
HHI Concentration	0,32		0,15		0,41		0,23	
Fossill Energy Contribution (%)	15,4%		46,3%		30,4%		23,8%	

Source: CLIMATESCOPE by Bloomberg NEF: <https://global-climatescope.org/>

¹⁶ Um índice de concentração HHI próximo a 0,25 sugere que a totalidade da matriz esteja concentrada em torno de aproximadamente quatro fontes relevantes distintas. Já um HHI de 0,33 sugere uma concentração em torno de aproximadamente três fontes relevantes distintas.

Brazil and Colombia have a large concentration of installed capacity in hydroelectric plants. In the case of Brazil, this energy corresponds to 56.8% (53.5% of large plants and 3.3% of small plants) of the total capacity. In the case of Colombia, this concentration is even greater, amounting to 66.5% (61.1% of large plants and 5.4% of small plants). The participation of this energy source in the case of Uruguay is also relevant: 30.8% (only large plants). Finally, in the case of Chile, this percentage is 23.2% (19.2% of large plants and 4% of small ones).

The fact that countries in the region have large installed capacities for hydroelectric power production has provided them, over time, with the accumulation of a class of relevant and strategic assets: broad interconnected electricity transmission and distribution networks, including hundreds of substations. For example, in the case of Brazil, a country of continental dimensions, the current number of substations is 772¹⁷, in addition to having 3 of the longest transmission lines in the world: (1) Belo-Monte – Rio de Janeiro transmission line, with 2,543 km; (2) Madeira River transmission link, with 2,385 km; and (3) Belo Monte - Estreito transmission line, with 2,092 km¹⁸.

Additionally, such complementarity between renewable energies would provide greater energy security to a potential 100% decarbonized and renewable system, since energy from hydroelectric origin can serve as

a back up to the system composed of intermittent renewable energy sources. It must also be considered that a good part of the hydroelectric assets in those countries has already been depreciated and, therefore, have a particularly low marginal cost of energy.

It was seen that the selected countries in the region have more decarbonized energy matrices than the world energy matrix. But the road to fully decarbonizing these matrices is still long. However, data on installed capacity in 2021 already show very promising signs in this regard, with emphasis on Brazil and Uruguay, whose contribution to installed capacity from fossil energy sources is only 15.5% and 23.8%, respectively. Although this percentage is still high for Chile, 46.3%, the contribution of solar and wind energy to its installed capacity is equally high, 28.6%.

The case of Colombia deserves attention. Although the percentage of fossil energy sources corresponds to 30.4% of its installed capacity, this same percentage for the case of sources used in electricity generation is only 16.6%, as can be seen in the table in figure 3, which reports the contribution of each of the different energy sources in the generation of electricity in these countries, measured in GWh (Gigawatt-hour). Although the numbers reported in the table still do not reflect its potential for generating electricity from solar and wind energy, the fact is that Colombia has considerable energy potential based on clean and renewable energies.

FIGURE 3. ELECTRICITY GENERATION (GWH) – SELECTED COUNTRIES 2021

Electricity Generation (GWh) - Selected Countries 2021								
Fontes	Brazil		Chile		Colombia		Uruguay	
	GWh	%	GWh	%	GWh	%	GWh	%
Biofuels and Biomass	51711	7,9%	2014	2,6%	788	1,1%	2026	14,3%
Mineral Coal	17585	2,7%	27444	35,4%	4246	5,7%	0	0,0%
Wind	72286	11,0%	5931	7,7%	61	0,1%	4962	35,1%
Natural Gas	86861	13,2%	14476	18,7%	7672	10,4%	0	0,0%
Geothermal	0	0,0%	320	0,4%	0	0,0%	0	0,0%
Big Hydro	341745	52,1%	12646	16,3%	54592	73,8%	6239	44,1%
Small Hydro	21073	3,2%	3829	4,9%	5904	8,0%	0	0,0%
Nuclear	14705	2,2%	0	0,0%	0	0,0%	0	0,0%
Other fossils	15146	2,3%	0	0,0%	0	0,0%	399	2,8%
Oil and Diesel	18244	2,8%	2704	3,5%	347	0,5%	103	0,7%
Solar Fotovoltaica	16752	2,6%	7918	10,2%	323	0,4%	425	3,0%
Solar Thermal	0	0,0%	154	0,2%	0	0,0%	0	0,0%
Total	656108	100,00%	77437	100,00%	73934	100,00%	14155	100,00%
HHI Concentration	0,32		0,15		0,41		0,23	
Fossil Energy Contribution (%)	15,4%		46,3%		30,4%		23,8%	

Source: CLIMATESCOPE by Bloomberg NEF: <https://global-climatescope.org/>

¹⁷ <https://www.bnamericas.com/pt/analise/destaque-mapa-das-subestacoes-de-transmissao-de-energia-do-Brazil#:~:text=Hoje%2C%20existem%20772%20subesta%C3%A7%C3%B5es%20em,nas%20regi%C3%B5es%20Sudeste%20e%20Sul.>

¹⁸ See: <https://www.power-technology.com/features/featurethe-worlds-longest-power-transmission-lines-4167964/>

¹⁹ Guimarães, Leonam (2021). “A Geopolítica da Energia de Baixo Carbono”. Em A Geopolítica da Energia do Século XXI. Guilherme Góes (Org). Editora Sinergia: Rio de Janeiro/RJ.

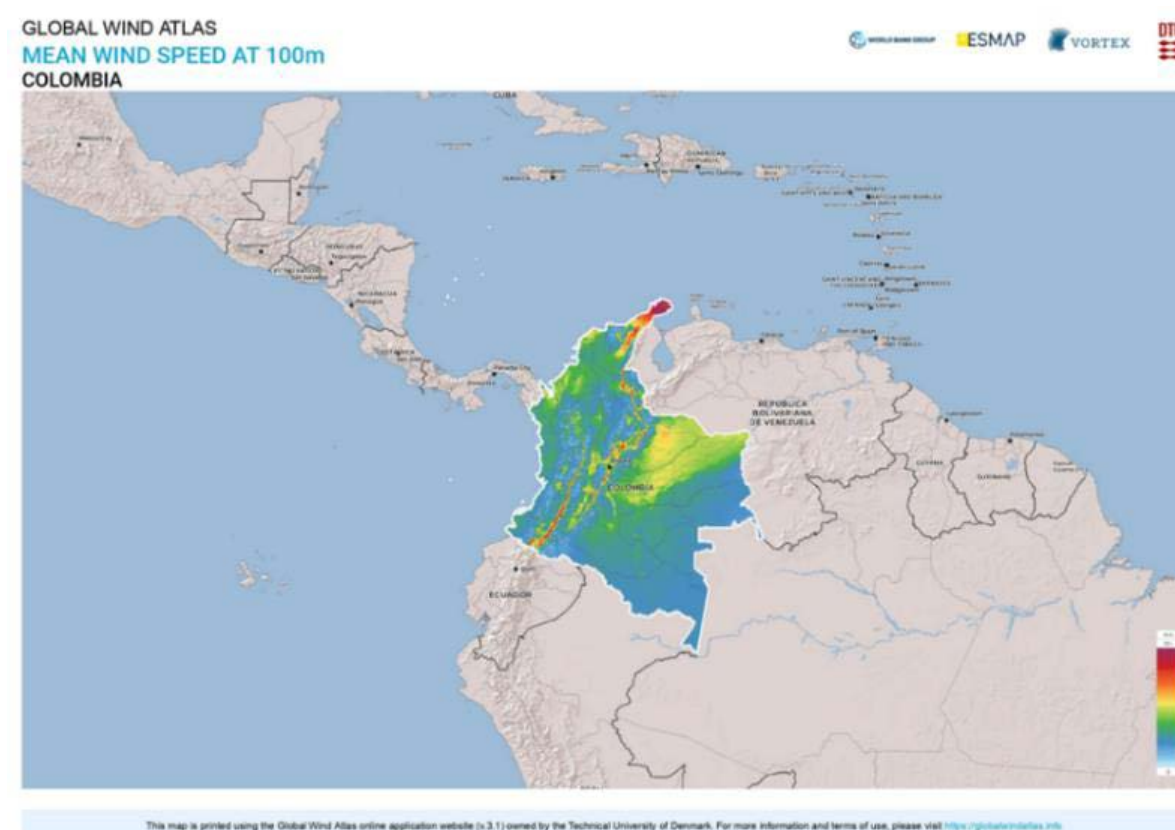
Colombia already has relatively clean electricity generation, since 70%-80% of its energy is generated by 30 hydroelectric plants distributed throughout the country (Velandia e Guzmán, 2021)²⁰. The country has made efforts to implement an energy diversification agenda prioritizing clean and renewable energy, including wind and solar photovoltaic energy.

Figure 4 shows the map of the average wind speed at 100 m (wind potential metric) in the different regions of the country. La Guajira region, a department located in the north of the country, plays a key role in this transition strategy, as it has great potential for the production of these forms of energy. For example, the average wind speed in the region is 9 m/s (20.1 miles/hour) at an altitude of 100 m, while the average daily solar radiation is 4.5 kWh/m² (Power Technology,

2020)²⁰. These are very promising parameters of productive potential. Additionally, according to IRENA estimates, "Colombia has the potential to have the fourth lowest price of H2V in 2050, surpassed only by China, Chile, and Morocco" (Bnamerica, 2022)²¹.

Therefore, Colombia has a location that combines potential for both wind energy production and photovoltaic solar energy production, while this complementarity provides competitive advantages for H2V production. Additionally, as will be seen below, the country has excellent port infrastructure in that region. The La Guajira region is approximately 340 km from the Port of Cartagena (one of the largest in LAC) and approximately 140 km from the Port of Santa Marta.²³

FIGURE 4. WIND POTENTIAL (AVERAGE WIND SPEED AT 100M) - COLOMBIA



Source: Worldbank Group, ESMAP, DTU Wind Energy & VORTEX

²⁰ Velandia e Guzmán (2021). "Colombia: A renewable energy powerhouse?". Global Americans. See: <https://theglobalamericans.org/2021/11/colombia-a-renewable-energy-powerhouse/>

²¹ Power Technology (2020). "Colombia boasts a strong solar PV and wind push to reduce dependence from vulnerable hydro generation to a resilient green generation mix, says GlobalData". See: <https://www.power-technology.com/comment/colombia-solar-pv-wind-dependence-hydro-generation/>

²² Bnamerica (2022). "Colombia will be the main exporter of hydrogen in Latin America and will have the fourth lowest price in the world by 2050". Bnamerica. See: <https://www.bnamerica.com/pt/noticias/colombia-sera-o-principal-exportador-de-hidrogenio-da-america-latina-e-tera-o-quarto-menor-preco-do-World-em-2050>

Returning to the data in Figure 3, we can see that, in the case of Brazil, the contribution of photovoltaic solar energy to electricity generation is still incipient (2.6%). On the other hand, the contribution of wind energy is already starting to gain relevance. Brazil is a country of continental dimensions, so it is normal that it presents different regions with greater or lesser potential for the production of solar photovoltaic and wind energy. In the case of wind potential, the Northeast and the extreme south regions stand out, as can be seen in figure 5, which presents the wind potential map of the country.

The country also has a wide range of territory where solar radiation is high and the potential for photovoltaic solar energy production is great. It is worth mentioning the Northeast region of the country which, like the region of La Guajira in Colombia, combines both potential for the production of wind energy and potential for the production of photovoltaic solar energy. Additionally, the region presents a negative correlation between the production curves of these energies, since the wind energy production curve

reaches its apex during the night, a very important characteristic for mitigating problems of intermittency of systems based on clean and renewable energies and for the production of H2V at very competitive prices.

Among the list of potential H2V applications is the generation of system back-up. According to a technical note produced by the Energy Research Company (EPE) - a public company linked to the Ministry of Mines and Energy of Brazil - entitled "Bases for the Consolidation of the Brazilian Hydrogen Strategy" (EPE, 2021), the application of hydrogen for back-up makes up the list of economically viable and competitive applications by the year 2030.²⁴

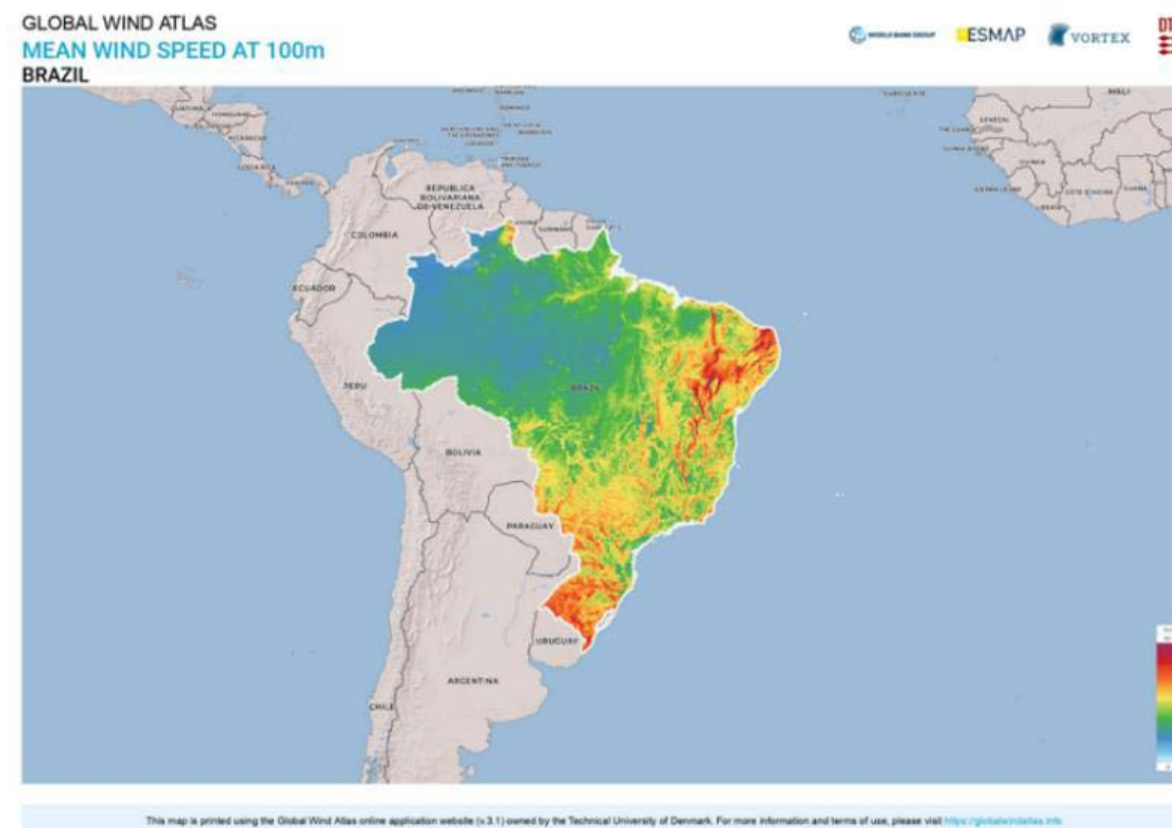
Still with regard to the data in Figure 3, photovoltaic solar energy and wind energy are already gaining relevance for electricity generation in Chile. Like the other countries analyzed, the tendency is for these percentages to grow quite quickly, since Chile also has great competitive potential when it comes to energy security based on the complementarity of clean and renewable energies.²⁵

²³ Colombia has several specificities that make it particularly attractive for Powershoring, in addition to its capacity for green and renewable energy production. These include its access to both the Atlantic and Pacific oceans, its relative proximity to the east and west coasts of the United States, and trade agreements with the US, EU, CPTPP, and Pacific Alliance. Ecopetrol is expected to soon begin construction of two green hydrogen production plants with a combined capacity of 120 megavolts of electrolysis. Hydrogen production is expected to begin in 2026.

²⁴ Brazil has exceptional potential for the production of biofuels and green energy from biomass, which is abundant and cheap in various parts of the country. Several biomass energy projects are in the development phase and will add to the other forms of green and renewable energy, increasing the diversification of energy sources and providing a significant competitive advantage and source of resilience. The country already makes massive use of biofuels in transportation, which places it in a leadership position for low-emission combustion engines worldwide. Hybrid car engine technologies that combine ethanol and electrification are also in development in the country, which could further increase this leadership. Recent simulations have shown that ethanol cars in Brazil emit less CO₂ than electric cars in Europe due to emissions in the value chains. Brazil is also developing innovative technologies for the production of green hydrogen from ethanol, which could become a relevant and determining factor in increasing the country's competitiveness in green and renewable energy. Fuel cells using ethanol conversion into hydrogen at the gas station or in the vehicle itself for electricity generation promise to be an important step in decarbonization and the green business agenda. The University of São Paulo, in partnership with SENAI, Raízen, Shell, Volkswagen, and Hytron, is involved in this project, and some plants are already in the development phase. In the same vein of alternative sources, the construction of a large plant for the production of green diesel and aviation kerosene (SAF) from soybean oil, macauba oil, and palm oil, as well as the production of green hydrogen from these same sources, is being studied in the state of Bahia.

²⁵ Chile has several favorable conditions to benefit from Powershoring and become a major platform for the production and export of green industrial products. Among them is the enormous surplus of green and renewable energy (solar), which can be used to supply factories and electrolyzers with important effects on competitiveness, and free trade agreements with preferential access to markets such as the United States, South Korea, Japan, China, European Union, Mexico, Canada, and the CPTPP.

FIGURE 5. WIND POTENTIAL (AVERAGE WIND SPEED AT 100M) - BRAZIL



Source: Worldbank Group, ESMAP, DTU Wind Energy & VORTEX

The Atacama Desert, an arid region with a territorial extension of 104,741 km², receives the highest solar radiation in the world, with approximately 4,000 hours of sunlight per year, which gives it a significant comparative advantage for the production of photovoltaic solar energy on a large scale. Wind energy is also produced at very competitive levels in the extreme south of Chile, in the Strait of Magellan. The region, which includes Patagonia and Tierra del Fuego, is among the windiest on the planet (see map in figure 6) along with Greenland, Somalia, and the Himalayas. The country also has a national policy and ambitious targets for H2V production, in addition to being home to a considerable and growing number of companies engaged in H2V projects.²⁶

²⁶ To maximize the benefits of green and renewable energy produced in these regions, it will be necessary to increase investments in energy transmission and storage networks.

FIGURE 6. WIND POTENTIAL (AVERAGE WIND SPEED AT 100M) - CHILE



Source: Worldbank Group, ESMAP, DTU Wind Energy & VORTEX

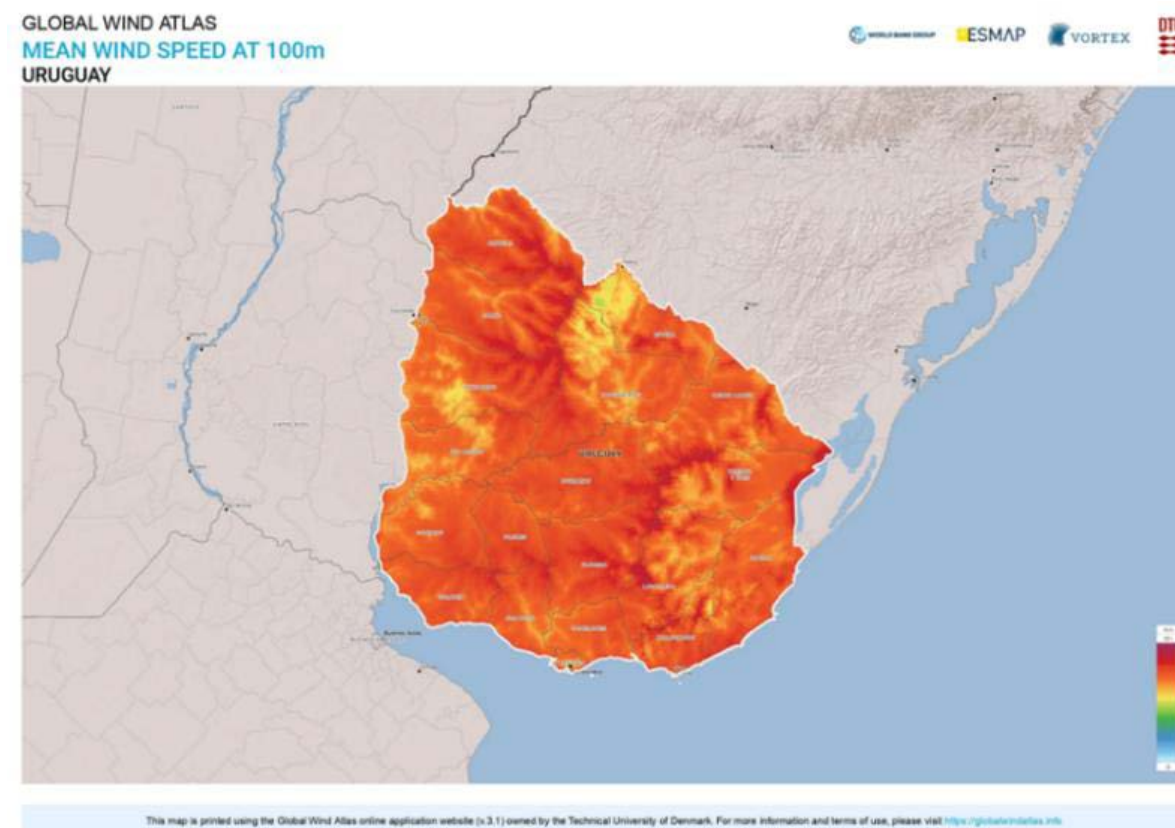
Uruguay has also stood out for its role in the production of clean and renewable energy. For example, “Between 2017 and 2020, 97% of Uruguay's electricity production came from renewable sources, making it a world leader alongside Denmark, Ireland, and Portugal” (Uruguay XXI, 2022)²⁷. According to the data in the table in Figure 3, wind energy contributes 35.1% to electricity generation, while photovoltaic solar energy contributes 3%. The country's wind potential is extremely high, as can be seen on the map in figure 7.

Concerning wind energy, the country has an installed capacity with 41 wind farms in operation, with an installed capacity of 1,506 MW. In terms of photovoltaic solar energy production parks, the country has 19 large-scale plants, with an approximate power of 229 MW, in addition to the power generated in small-scale plants, which add up to a capacity of 30 MW (Uruguay XXI, 2022).²⁸

²⁷ Uruguay XXI (2022). “Energías Renovables Uruguay”. Promoción de Inversiones, Exportaciones e Imagen País. See: <https://www.uruguayxxi.gub.uy/uploads/informacion/bc3579a748313b4980f6ff6208110ed0be63a7fd.pdf>

²⁸ Uruguay also has conditions that make it particularly attractive for Powershoring. These include political and institutional stability, ambitious government decarbonization policies, and infrastructure. In this regard, it is worth highlighting the Ferrocarril Central, an important railway that will soon be available and could become a green industrial corridor associated with the Port of Montevideo.

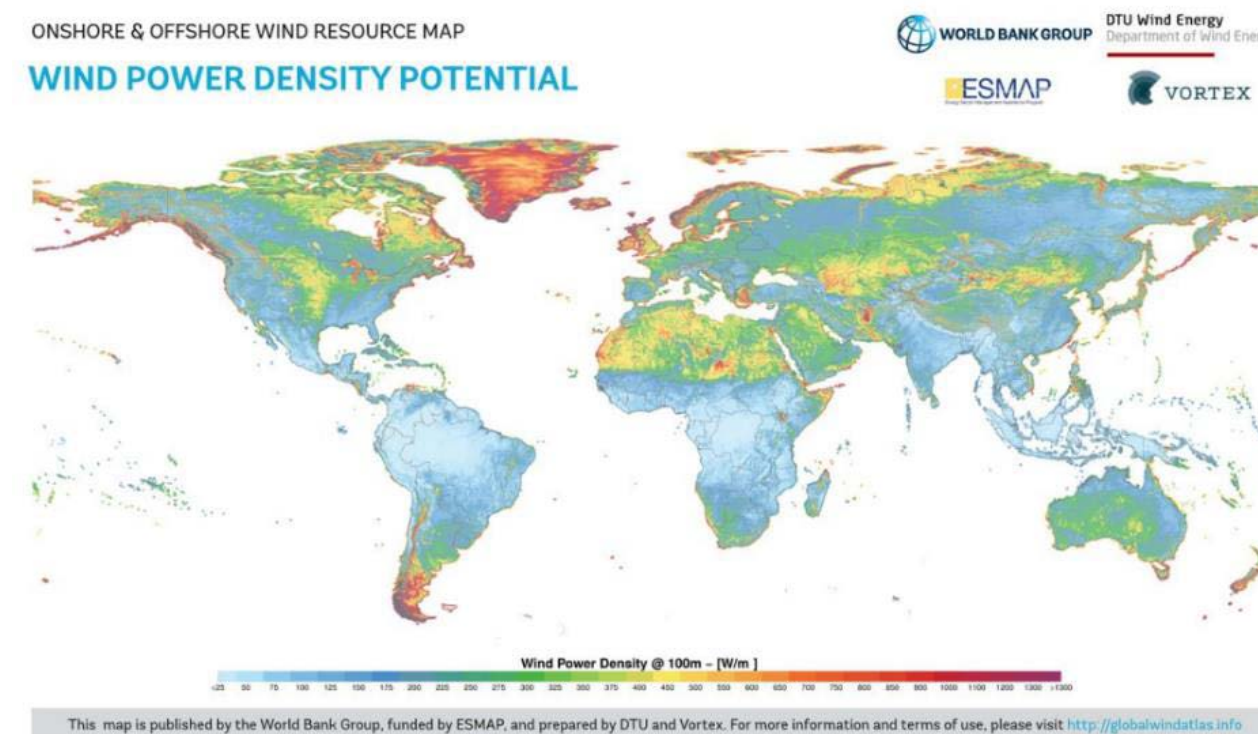
FIGURE 7. WIND POTENTIAL (AVERAGE WIND SPEED AT 100M) - URUGUAY



Source: Worldbank Group, ESMAP, DTU Wind Energy & VORTEX

Let us now see the potential of LAC compared to other regions of the world, for different sources of clean and renewable energy. Figure 8 presents the map of wind energy production potential around the world. In addition to the countries in the LAC region, Greenland also stands out; the Canadian regions of Quebec and Nunavut, the states of the center of the US, as well as Alaska, the United Kingdom, Scandinavia, northern Russia, Kazakhstan, Afghanistan, China; Mongolia, Oceania, West Africa, and North Africa.

FIGURE 8. WIND POTENTIAL MAP - WORLDWIDE

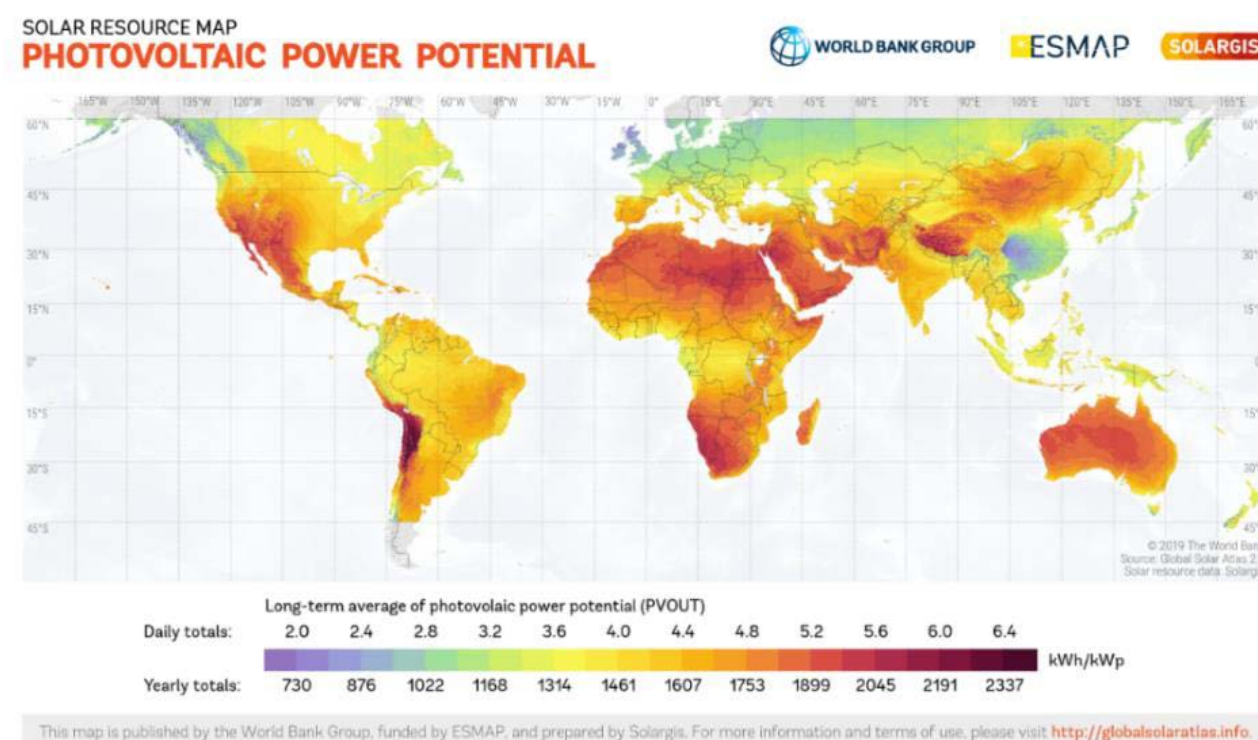


Source: Worldbank Group, ESMAP, DTU Wind Energy & VORTEX

Figure 9 presents the map of photovoltaic energy production potential²⁹ around the world. In addition to LAC, the US states of California, Arizona, New Mexico, and Texas; Australia; North and South Africa, the Arabian Peninsula and the Persian Gulf, China and Mongolia also stand out.

²⁹ Represented in terms of PV power output (PVOUT), measured in kWh/kWp, which means Kilowatt-hour (kWh) per Kilowatt peak power (kWp).

FIGURE 9. SOLAR POTENTIAL MAP - WORLD



Source: Worldbank Group, ESMAP, DTU Wind Energy & VORTEX

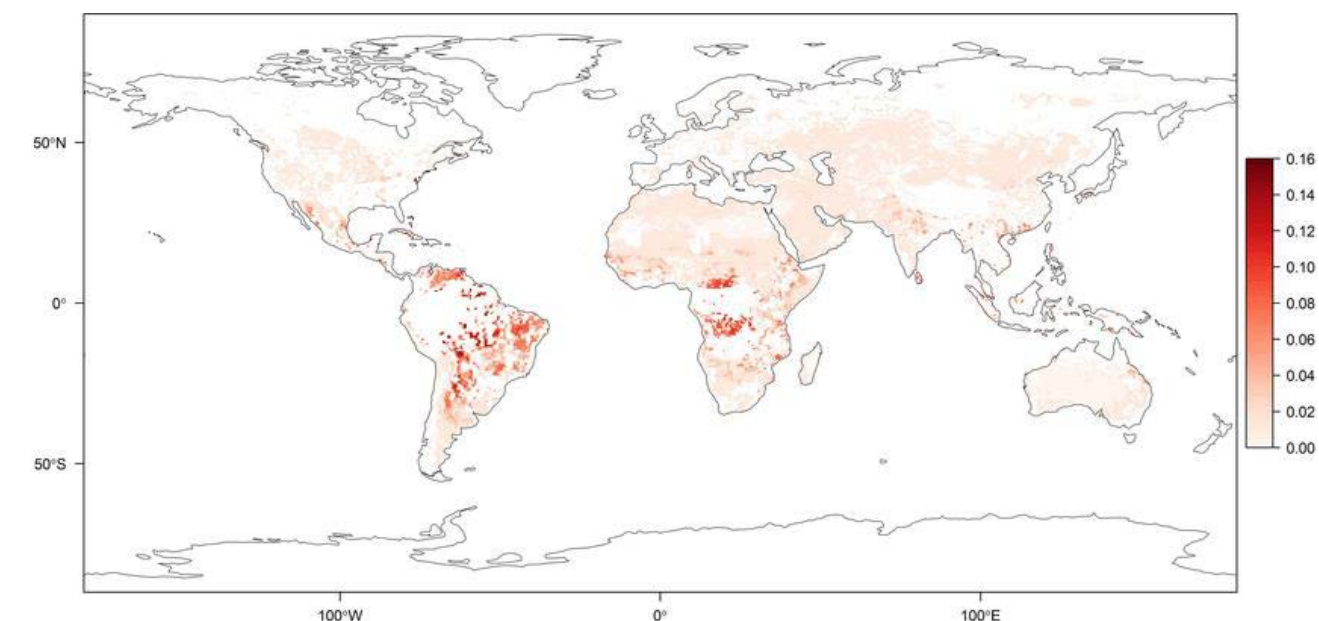
Figure 10 shows the map of a projection of global bioenergy potential for the year 2050. Such results were obtained from a simulation modeling conducted by Wu et al (2019)³⁰.

The authors work with nine different types of scenarios for mitigating climate risks, including different policies and environmental protection measures. Although the results have varied considerably between the different scenarios, in all of them the groups classified as “Brazil”, “Rest of South America” and “Rest of Africa” (excluding “North Africa”) concentrate approximately 3/4 of the global production of bioenergy.

In the “Full Environmental Policy” scenario, production costs (US\$/GJ) are the highest possible. The opposite occurs in the case of the “No Policy” scenario, in which production costs are the lowest. This is because the bioenergy production potential depends on land use, which can vary significantly, depending on soil and biodiversity protection policies. In the “No Policy” scenario, the estimated production of the “Brazil” group is 68 EJ/year (28% of the global production potential); that of the “Rest of South America” group is 67 EJ/year (27% of global production potential); and the “Rest of Africa” group is 54 EJ/year (22% of global production potential).

³¹ Wu et al (2019). “Global advanced bioenergy potential under environmental protection policies and societal transformation measures”. GCB Bioenergy. 2019 (11): p.1041–1055.

FIGURE 10. BIOENERGETIC POTENTIAL MAP 2050



Source: Wu et al (2019)

As can be seen from the information reported in the previous paragraphs, different regions of the globe have a lot of potential for the production of different types of clean and renewable energies. However, a much smaller number of regions have the potential for joint and combined production of all forms of clean and renewable energy. LAC fits into this second group of regions.

In summary, the LAC region already has relatively clean energy matrices. The potential for expanding the production of clean and renewable energies already produced (such as photovoltaic solar, wind, biomass, and biofuels) is enormous. Add to that the enormous potential for large-scale H2V production at competitive prices, and all this in an environment where hydroelectric power production and the infrastructure of transmission, distribution, and substation networks are already well developed. In short, LAC has virtually unique conditions to produce green energy at highly competitive prices and become an engine for promoting decarbonization and economic and social development.

INSTITUTIONS AND ENERGY AND ENVIRONMENTAL REGULATION

Despite the aforementioned energy potential, these countries have a solid set of institutions, with technical staff specialized in energy and environmental planning, as well as in the formulation and execution of public policies in these areas. Figure 11 presents a table with a representative set of these institutions. These are classified into three types: (i) national energy agencies; (ii) environmental licensing agencies; and (iii) regulatory agencies. The role of national energy agency is exercised by the Ministries of Mines and Energy in all four countries. In the cases of Brazil and Colombia, there is also the presence of units specialized in research and planning, as is the case of the Energy Research Company (*Empresa de Pesquisa Energética*) - EPE, in Brazil, and Energy Mining Planning Unit (*Unidad de Planeación Minero Energética*) - UPME, in Colombia.

All countries have environmental licensing units. In the cases of Brazil, Chile, and Colombia, this task is under the responsibility of autonomous services created by law. These are the cases of the Brazilian Institute of the Environment and Renewable Natural Resources (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis*), IBAMA (created by Law No. 7,735 on February 22, 1989) in Brazil, the Superintendence of the Environment (*Superintendencia del Medio Ambiente*), SMA (created by Law No. 20,417 on January 26, 2010) in Chile, and the National Authority for Environmental Licensing (*Autoridad Nacional de Licencias Ambientales*), ANLA (created by Decree-Law No. 3,573 on September 2011) in Colombia. In the case of Uruguay, the task is assigned to DINAMA, a directorate linked to the organizational structure of the Ministry of Housing and Territorial Planning.

With regard to economic regulation, all countries have agencies responsible for such activities. Institutional designs vary from country to country. For example, in the case of Uruguay, there is a single regulatory

agency responsible for energy services (including water services), the Regulatory Unit for Energy and Water Services (*Unidad Reguladora de Servicios de Energía y Agua*) - URSEA. In the case of Colombia, there are three agencies, in which the Superintendence of Residential Public Services (*Superintendencia Servicios Públicos Domiciliarios*) - SSPD regulates services aimed at households. The Energy and Gas Regulation Commission (*Comisión de Regulación de Energía y Gas*) - CREG regulates monopolies and the National Hydrocarbon Agency (*Agencia Nacional de Hidrocarburos*) - ANH has the legal function of, among others, entering into and administering contracts and agreements for the prospecting and exploitation of hydrocarbons owned by the country.

Brazil has a regulatory structure with two agencies: (i) the National Petroleum, Natural Gas and Biofuels Agency (*Agência Nacional do Petróleo, Gás Natural e Biocombustíveis*) - ANP, which is the regulatory body for activities that integrate the oil and natural gas and biofuels industries in the country; and (ii) the National Electric Energy Agency (*Agência Nacional de Energia Elétrica*) - ANEEL, whose purpose is to regulate and supervise the production, transmission, distribution, and commercialization of electric energy. Finally, Chile also has two agencies: (i) the National Energy Commission (*Comisión Nacional de Energía*) - CNE, responsible for analyzing prices, tariffs, and technical standards to which energy producing, generating, transporting and distributing companies must adhere; and (ii) the Superintendence of Electricity and Fuels (*Superintendencia de Electricidad y Combustibles*) - SEC, which oversees the operation of electricity, gas, and fuel services, with regard to their safety, quality, and price.

Countries, therefore, have institutions to help them reach a more ambitious stage, namely, making the energy transition an opportunity for economic development.

FIGURE 11. ENERGY AND ENVIRONMENT INSTITUTIONS, SELECTED COUNTRIES

Energy and Environment Institutions, Selected Countries			
Country	National energy agencies	Licensing agencies	Regulatory agencies
Brazil	MME (Ministério de Minas e Energia) https://www.gov.br/mme/pt-br	IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) https://www.gov.br/ibama/pt-br	ANP (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis) https://www.gov.br/anp/pt-br ANEEL (Agência Nacional de Energia Elétrica) https://www.gov.br/aneel/pt-br
Chile	Ministerio de Energi https://energia.gob.cl/	SMA (Superintendencia del Medio Ambiente) https://portal.sma.gob.cl/	CNE (Comisión Nacional de Energía) https://www.cne.cl/ SEC (Superintendencia de Electricidad y Combustibles) www.sec.cl
Colombia	MME (Ministerio de Minas y Energía) https://www.minenergia.gov.co/ UPME (Unidad de Planeación Minero Energética) https://www1.upme.gov.co/	ANLA (Autoridad Nacional de Licencias Ambientales) https://www.anla.gov.co/	CREG (Comisión de Regulación de Energía y Gas) https://www.creg.gov.co/ ANH (Agencia Nacional de Hidrocarburos) https://www.anh.gov.co/ SSPD (La Superintendencia de Servicios Públicos Domiciliarios) https://www.superservicios.gov.co/
Uruguay	MIEM (Ministerio de Industria, Energía y Minería) https://www.gub.uy/ministerio-industria-energia-mineria/	DINAMA (Dirección Nacional de Medio Ambiente) https://www.gub.uy/ministerio-vivienda-ordenamiento-ter	URSEA (Unidad Reguladora de Servicios de Energía y Agua) https://www.gub.uy/unidad-reguladora-servicios-energia-agua/

PORT INFRASTRUCTURE

A point already highlighted in previous paragraphs is that the selected countries already have a satisfactory port infrastructure for Powershoring. In the cases of Brazil and Colombia, some of their port complexes are located exactly in the same regions where plants for the production of photovoltaic solar energy, onshore and offshore wind energy, and projects for plants for the production of H2V will be established. In the case of Brazil, this is the case of the Northeast region of the country, served by the ports (container terminals) of Itaquí, Pecém, Fortaleza, Natal, Recife, Suape, and Salvador.³¹ In the case of Colombia, as previously mentioned, the joint production of photovoltaic solar energy, wind energy, and H2V projects are being developed in the region of La Guajira, close to the Ports of Cartagena and Santa Marta.

In the case of Uruguay, its small territorial extension ends up exerting natural effects of agglomeration of activities and logistical advantages. The country is served by the Port of Montevideo. The case of the extreme south of Brazil is similar to the case of Uruguay, and the region is served by the Port of Rio Grande.

As we have seen, Chile is one of the countries with the greatest potential for producing solar photovoltaic and

wind energy in the world. The potential of solar energy located in the Atacama Desert is supported by the Port of Antofagasta. The wind potential is located in the extreme south of the country, in the Strait of Magellan, and is served by the Ports of Punta Arenas and Puerto Natales.

The table in Figure 12 lists the container terminal ports for each of the four selected countries, in addition to providing some information on infrastructure (size and type) and location (coordinates). Additionally, the table provides information on the distances from each of these ports to the ports of Rotterdam (Europe), Shanghai (East Asia), New York (East Coast of the US), and Los Angeles (West Coast of the US), which are some of the reference ports for foreign trade in LAC. Distances are expressed in nautical miles and the estimated duration of the trip (in days and hours) is based on a nautical speed of 10 knots. It can be concluded that the region is geographically well positioned to meet the interests of companies that aim to produce to export to the largest world markets.

Therefore, countries already have port services in areas with the highest potential for generating green energy, which corresponds to a fundamental enabling element for Powershoring in the region.



Photo: Adobe Stock

³¹ It is necessary to include Porto Sul, in Bahia, which is under construction.

FIGURE 12 CONTAINER TERMINALS – SELECTED COUNTRIES AND DISTANCES TO ROTTERDAM, SHANGHAI, NY, AND LA

Container Terminals				
Country	Port	Size	Type	Coordinate
Brazil	Manaus	Medium	River	-3° -8' -38" S, -60° 0' -30" W
	Vila do Conde	Small	Pier, Jetty of Wharf	-1° -33' -9" S, -48° -44' 0" W
	Itaqui	Medium	Porto Maritimo	-2° -34' -10" S, -44° -20' -31" W
	Pecem	Small	Pier, Jetty of Wharf	-3° -34' -17" S, -38° -50' -42" W
	Fortaleza			-3° -43' -51" S, -38° -36' -51" W
	Natal	Small	Harbor	-5° -46' 0" S, -35° -12' 0" W
	Recife			-8° -2' -1" S, -34° -52' -29" W
	Suape			-8° -24' -29" S, -34° -58' -58" W
	Salvador	Medium	Harbor	-12° -58' -16" S, -38° -30' -5" W
	Vitoria	Medium	Porto Maritimo	-20° -20' -37" S, -40° -17' -36" W
	Rio de Janeiro	Medium	Porto Maritimo	-22° -53' -60" S, -43° -12' 0" W
	Sepetiba	Tiny	Porto Maritimo	-22° -55' -14" S, -43° -49' -50" W
	São Sebastião	Small	Pier, Jetty of Wharf	-23° -48' 0" S, -45° -25' -18" W
	Santos	Medium	Porto Maritimo	-23° -58' -25" S, -46° -19' -14" W
	Paranaguá	Medium	Porto Maritimo	-25° -33' -14" S, -48° -30' -26" W
	Itapoa			-26° -11' -2" S, -48° -36' -9" W
	São Francisco	Small	Porto Maritimo	-26° -16' -13" S, -48° -31' -35" W
	Itajaí	Medium	Porto Maritimo	-26° -53' -60" S, -48° -38' -60" W
	Imbituba	Small	Harbor	-28° -14' -8" S, -48° -39' -31" W
	Porto Alegre	Medium	Porto Maritimo	-30° -3' -7" S, -51° -13' -52" W
	Navegantes			-30° 0' -6" S, -51° -12' -24" W
Chile	Rio Grande	Medium	Porto Maritimo	-32° -2' -48" S, -52° -5' -10" W
	Arica	Medium	Porto Maritimo	-18° -29' -25" S, -70° -19' -4" W
	Iquique	Small	Porto Maritimo	-20° -13' -26" S, -70° -8' -41" W
	Puerto Angamos			-23° -3' -58" S, -70° -23' -22" W
	Antofagasta	Medium	Porto Maritimo	-23° -39' -25" S, -70° -23' -51" W
	Valparaíso	Medium	Porto Maritimo	-33° -3' -1" S, -71° -38' -20" W
	San Antonio	Medium	Harbor	-33° -34' -2" S, -71° -36' -31" W
	Lirquen	Small	Porto Maritimo	-36° -41' -40" S, -72° -57' -46" W
	San Vicente			-36° -43' 0" S, -73° -7' -59" W
	Coronel	Small	Pier, Jetty of Wharf	-37° 0' -48" S, -73° -8' -50" W
	Puerto Montt	Small	Porto Maritimo	-41° -28' -1" S, -72° -56' -32" W
	Puerto Chacabuco	Small	Harbor	-45° -24' -21" S, -73° -17' -13" W
Colombia	Puerto Natales	Tiny	Pier, Jetty of Wharf	-51° -45' -34" S, -72° -26' -21" W
	Punta Arenas	Tiny	Pier, Jetty of Wharf	-53° -6' -6" S, -70° -56' -28" W
	Santa Marta	Small	Harbor	11° 14' 11" N, -74° -12' -55" W
	Barranquilla	Medium	Porto Maritimo	10° 58' 30" N, -74° -45' -52" W
	Cartagena	Grande	Porto Maritimo	10° 24' 9" N, -75° -31' -12" W
Uruguay	Turbo	Small	Porto Maritimo	8° 4' 24" N, -76° -52' -38" W
	Buenaventura	Medium	Pier, Jetty of Wharf	3° 53' 18" N, -77° -2' -39" W
	Montevideo	Medium	Porto Maritimo	-34° -54' -24" S, -56° -11' -45" W

Selected Countries							
Port-to-Port (distance in nautical mlles at a speed of 10 knots)							
Rotterdam		Xangai		Nova Iorque		Angeles	
Distância	Days	Distância	Days	Distância	Days	Distância	Days
5030	20 days 23 hours	11592	48 days 07 hours	3781	15 days 18 hours	5933	24 days 17 hours
4180	17 days 10 hours	10926	45 days 13 hours	2930	12 days 05 hours	5267	21 days 23 hours
4108	17 days 03 hours	11087	46 days 05 hours	3073	12 days 19 hours	5428	22 days 15 hours
4016	16 days 18 hours	11328	47 days 05 hours	3300	13 days 18 hours	5726	23 days 21 hours
4016	16 days 18 hours	11328	47 days 05 hours	3300	13 days 18 hours	5726	23 days 21 hours
4059	16 days 22 hours	11084	46 days 04 hours	3528	14 days 17 hours	5982	24 days 22 hours
4174	17 days 09 hours	10984	45 days 18 hours	3670	15 days 07 hours	6124	25 days 12 hours
4174	17 days 09 hours	10984	45 days 18 hours	3670	15 days 07 hours	6124	25 days 12 hours
4558	19 days 00 hours	10997	45 days 20 hours	4057	16 days 22 hours	6511	27 days 03 hours
4974	20 days 17 hours	10857	45 days 06 hours	4474	18 days 15 hours	6928	28 days 21 hours
5243	21 days 20 hours	10925	45 days 13 hours	4743	19 days 18 hours	7197	30 days 00 hours
5243	21 days 20 hours	10925	45 days 13 hours	4743	19 days 18 hours	7197	30 days 00 hours
5373	22 days 09 hours	11023	45 days 22 hours	4873	20 days 07 hours	7327	30 days 13 hours
5430	22 days 15 hours	11056	46 days 02 hours	4930	20 days 13 hours	7384	30 days 18 hours
5552	23 days 03 hours	11111	46 days 07 hours	5052	21 days 01 hours	7506	31 days 07 hours
6101	25 days 10 hours	11279	47 days 00 hours	5604	23 days 08 hours	7551	31 days 11 hours
6101	25 days 10 hours	11279	47 days 00 hours	5604	23 days 08 hours	7551	31 days 11 hours
5951	24 days 19 hours	11129	46 days 09 hours	5454	22 days 17 hours	7401	30 days 20 hours
6754	28 days 03 hours	9874	41 days 03 hours	3925	16 days 09 hours	4222	17 days 14 hours
6820	28 days 10 hours	9940	41 days 10 hours	3991	16 days 15 hours	4288	17 days 21 hours
6965	29 days 01 hours	10085	42 days 01 hours	4136	17 days 06 hours	4433	18 days 11 hours
7455	31 days 02 hours	10134	42 days 05 hours	4626	19 days 07 hours	4806	20 days 01 hours
7484	31 days 04 hours	10134	42 days 05 hours	4655	19 days 10 hours	4835	20 days 04 hours
7645	31 days 21 hours	10042	41 days 20 hours	4816	20 days 02 hours	4931	20 days 13 hours
7642	31 days 20 hours	10038	41 days 20 hours	4813	20 days 01 hours	4934	20 days 13 hours
8000	33 days 08 hours	10035	41 days 20 hours	5171	21 days 13 hours	5255	21 days 22 hours
7416	30 days 22 hours	9768	40 days 17 hours	6916	28 days 20 hours	5865	24 days 11 hours
4478	18 days 16 hours	8970	37 days 09 hours	1783	7 days 10 hours	3311	13 days 19 hours
4515	18 days 20 hours	8948	37 days 07 hours	1803	7 days 12 hours	3289	13 days 17 hours
4587	19 days 03 hours	8886	37 days 01 hours	1850	7 days 17 hours	3227	13 days 11 hours
5194	21 days 15 hours	8601	35 days 20 hours	2365	9 days 21 hours	3047	12 days 17 hours
6244	26 days 00 hours	11066	46 days 03 hours	5748	23 days 23 hours	7163	29 days 20 hours

EXPORT PROCESSING ZONES - EPZ

In addition to examining the institutional and port infrastructure of the selected economies, as well as the distances to ports in Europe, Asia, and North America, we now seek to identify the existence of industrial districts with differentiated tax regimes through the constitution of Processing Zones Export – EPZ. The Portal Tributário website defines EPZs in the following terms::

“They are characterized as areas of free trade with the regions abroad, destined to the installation of companies directed to the production of goods to be commercialized abroad, the provision of services linked to the industrialization of the goods to be exported or the provision of services

to be commercialized or destined exclusively abroad, considered primary zones for the purpose of customs control” (Portal Tributário)³².

SEBRAE defines the EPZs as “industrial districts, whose companies benefit from the suspension of taxes to export”³³

The map in Figure 13 identifies the EPZs established in South American countries. The table in Figure 14 lists the EPZs established in the selected countries, including information on (i) the identification of the EPZ; (ii) the identification of the administrator of the EPZ; and (iii) the legal nature of the administrator.

FIGURE 13 EPZs IN SOUTH AMERICA



Source: Open Zone MapBETA, <https://www.openzonemap.com/map>



Photo: Unsplash

As can be seen, Brazil has a high number of EPZs distributed throughout its extensive territory. They add up to a total of 22 EPZs. The justification for such a high number of EPZs is associated with their number of federative units (FU). Brazil has 27 FU's, 26 States, and the Federal District. In Brazil, the administration of some taxes is the responsibility of the state, which enjoys constitutional autonomy to set rates and define tax exemptions and suspensions. On the other hand, Colombia does not have any EPZ. Chile and Uruguay have one EPZ each. For comparison, Argentina and Bolivia have 5 and 4 EPZs, respectively.

For the consolidation of a successful Powershoring strategy, it may be convenient for Colombia and Chile to assess the costs and benefits of expanding their number

of EPZs. Chile's EPZ is located in Arica, in the extreme north of the country, on the border with Peru. We have already seen that the country's solar energy potential is concentrated in the Atacama Desert region. But the distance between the EPZ of Arica and Atacama is more than 1,000 km in a straight line and 1,300 km by road, while the distance from the EPZ to the Strait of Magellan (where the wind energy potential is located) is more than 3,800 km in a straight line and 4,900 km on roads. In the case of Colombia, it would be worth evaluating the costs and benefits of setting up an EPZ in the La Guajira region.

This section showed that LAC countries already have many of the necessary conditions to become hubs specialized in providing clean, renewable, and safe energy solutions for 21st-century industries.

³² See: <https://www.portaltributario.com.br/guia/zpe.html>

³³ See: <https://www.sebrae.com.br/sites/PortalSebrae/ufs/ap/informes/zona-de-processamento-de-exportacao,dfd97640b34b6510VgnVCM1000004c00210aRCRD>

FIGURE 14 EPZS - SELECTED COUNTRIES

Export Processing Zones - ZPE - Selected Countries			
Country	ZPE	Management	Management Type
Brazil	ZPE do Acre (AC)	Administradora da Zona de Processamento de Exportação do Acre, SA	Public-Private Partnership
	ZPE de Boa Vista (RR)	Administradora da Zona de Processamento de Exportação de Boa Vista	Private
	ZPE de Barcarena (PA)	Companhia Administradora da ZPE de Barcarena	Public-Private Partnership
	ZPE de Araguaína (TO)	Companhia Administradora da ZPE/Tocantins	Private
	ZPE de São Luís (MA)	Secretaria da Indústria e Comércio	Public
		Companhia Administradora da Zona de Processamento de Exportação de Parnaíba-PI	
	ZPE de Parnaíba (PI)	S/A.	Private
	ZPE do Pecém (CE)	Empresa Administradora da Zona de Processamento de Exportação de Pecém S/A.	Private
	ZPE de Macaíba (RN)	Administradora da Zona de Processamento de Exportação de Macaíba	Private
	ZPE de João Pessoa (PB)	Cia. de Desenvolvimento Industrial da Paraíba	Private
	ZPE de Suape (PE)	ZPE Administradora, SA	Private
	ZPE de Barra dos Coqueiros (SE)	Companhia Administradora da Zona de Processamento de Exportação de Sergipe	Private
		ZPEX - Administradora da Zona de Processamento de Exportação de Teófilo Otoni,	
	ZPE de Teófilo Otoni (MG)	SA	Private
	ZPE de Uberaba (MG)	Cassu Participações	Public-Private Partnership
	ZPE de Aracruz (ES)	Cia. Administradora da Zona de Processamento de Exportação de Aracruz	Public
	ZPE do Açu (RJ)	Rochas do Açu Ltda	Public-Private Partnership
	ZPE de Itaguaí (RJ)	Casa Civil e Sec. do Desenvolvimento Econômico	Public
	ZPE de Fernandópolis (SP)	Administradora da Zona de Processamento de Exportação de Fernandópolis	Public-Private Partnership
	ZPE de Imbituba (SC)	Imbituba Administradora da Zona de Processamento de Exportação	Public
	ZPE de Rio Grande (RS)	Companhia Administradora da ZPE do Rio Grande	Private
	ZPE de Bataguassú (MS)	Empresa Gestora da Zona de Processamento e Exportação	Private
			Public
	ZPE de Cáceres (MT)	Administradora da ZPE de Cáceres S/A	Public
Chile	Chacalluta Arica Industrial Park	ZOFRI, SA	Public-Private Partnership
Uruguay	Colonia Free Zone	Grupo Continental Zona Franca, SA	Private

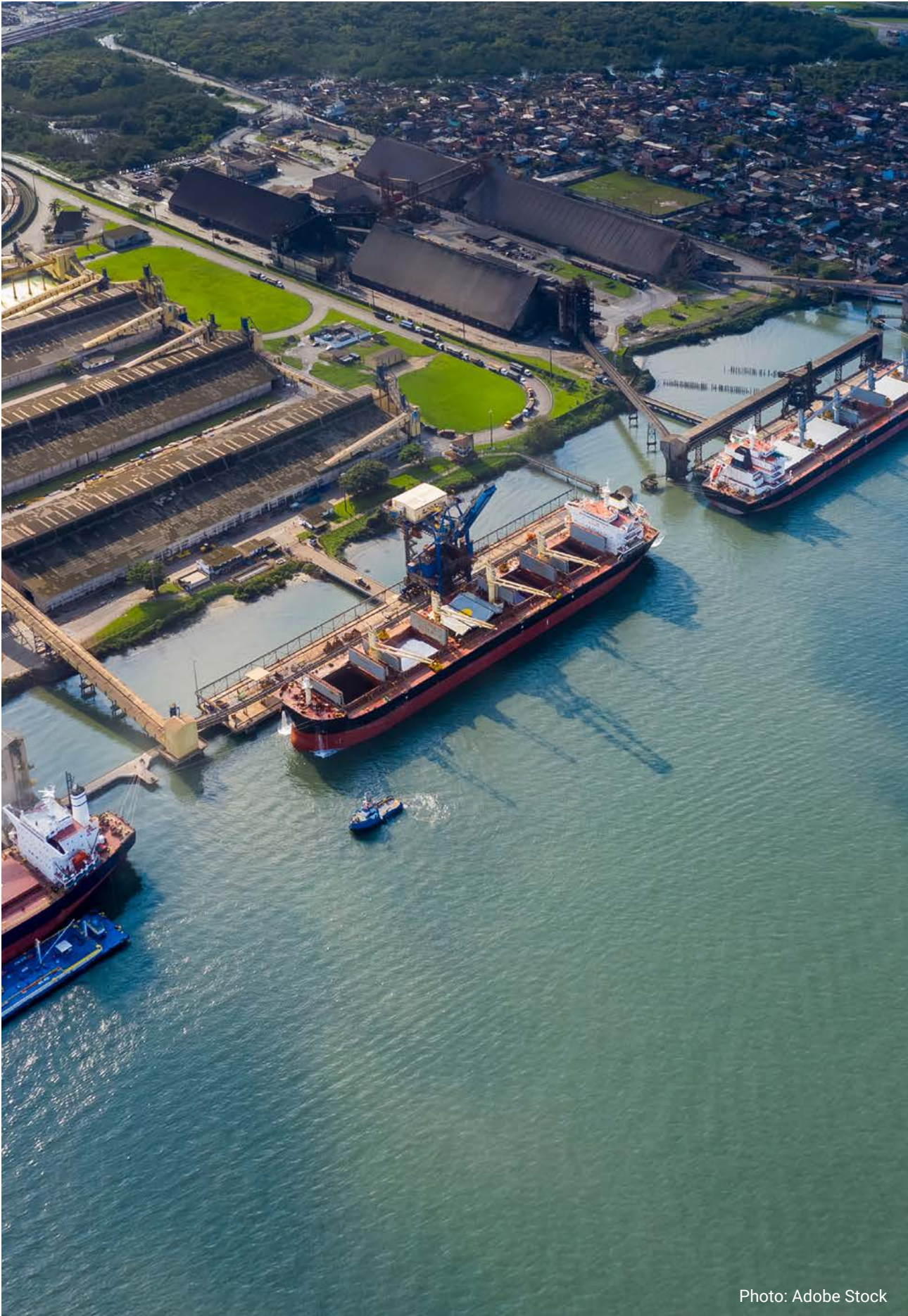


Photo: Adobe Stock

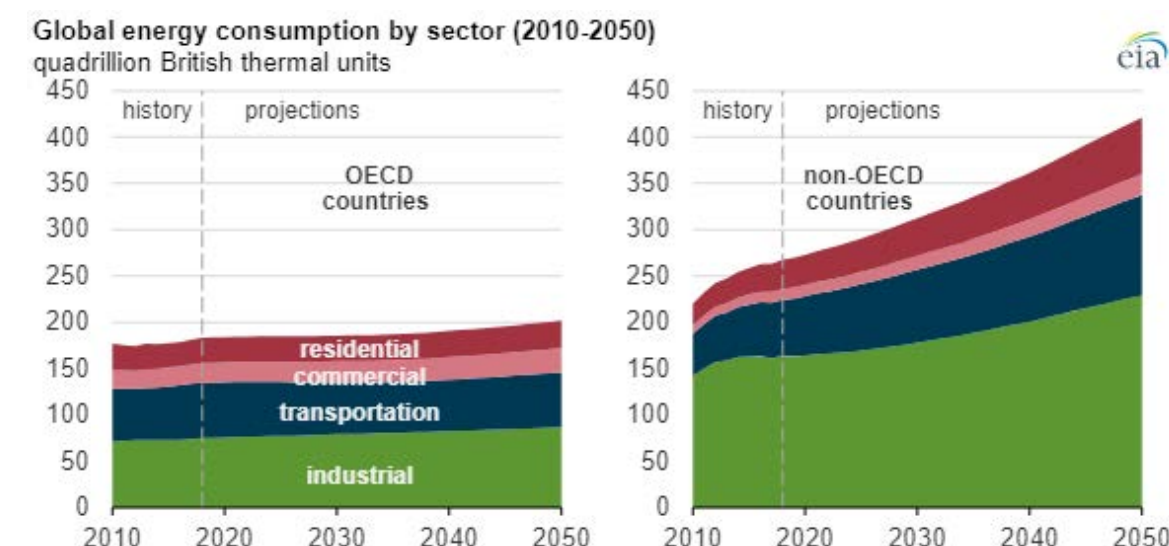
POWERSHORING: FOR WHOM?

Photo: Adobe Stock

INCREASING DEMAND FOR ENERGY

The challenge of transitioning to a decarbonized and renewable global energy matrix is not the most trivial and requires a disproportionately large effort with current levels of energy consumption. But, with the expectation of a significant increase in energy consumption in the coming decades, the required effort will be even greater. Figure 15 presents estimates of energy consumption up to 2050 for the set of OECD member countries and for developing economies. The estimates are divided by industrial, transport, commercial, and residential sectors.

FIGURE 15. ESTIMATES OF ENERGY SECTOR CONSUMPTION – OECD AND NON-DEVELOPED COUNTRIES



Source: U.S. Energy Information Administration, International Energy Outlook 2019

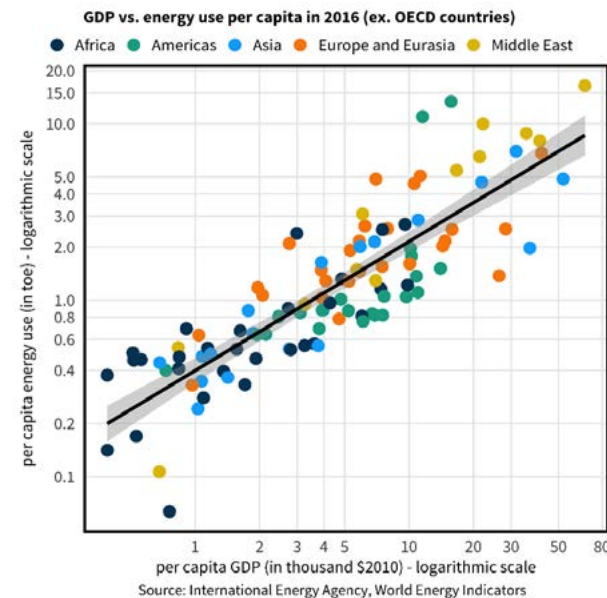
Estimates were made with data from the US Energy Information Administration (EIA, 2019)³⁴ and project a slight growth in energy consumption for OECD countries between 2020 and 2050, regardless of the type of consumption. On the other hand, projected growth estimates for non-OECD countries over the same period are high and generalized across different sectors, with emphasis on residential consumption and the transport

sector. In both groups of countries, the industrial sector accounts for the largest share of energy consumption.

To help understand why energy consumption projections for the coming decades vary so much between the two groups of countries, we examined the correlation between per-capita income levels and per-capita energy consumption levels (figure 16).

³⁴ EIA (2019). "International Energy Outlook 2019: With Projections to 2050". U.S. Energy Information Administration. U.S. Department of Energy, #IEO2019: Washington, DC.

FIGURE 16. RELATION BETWEEN PER-CAPITA INCOME AND PER-CAPITA ENERGY CONSUMPTION



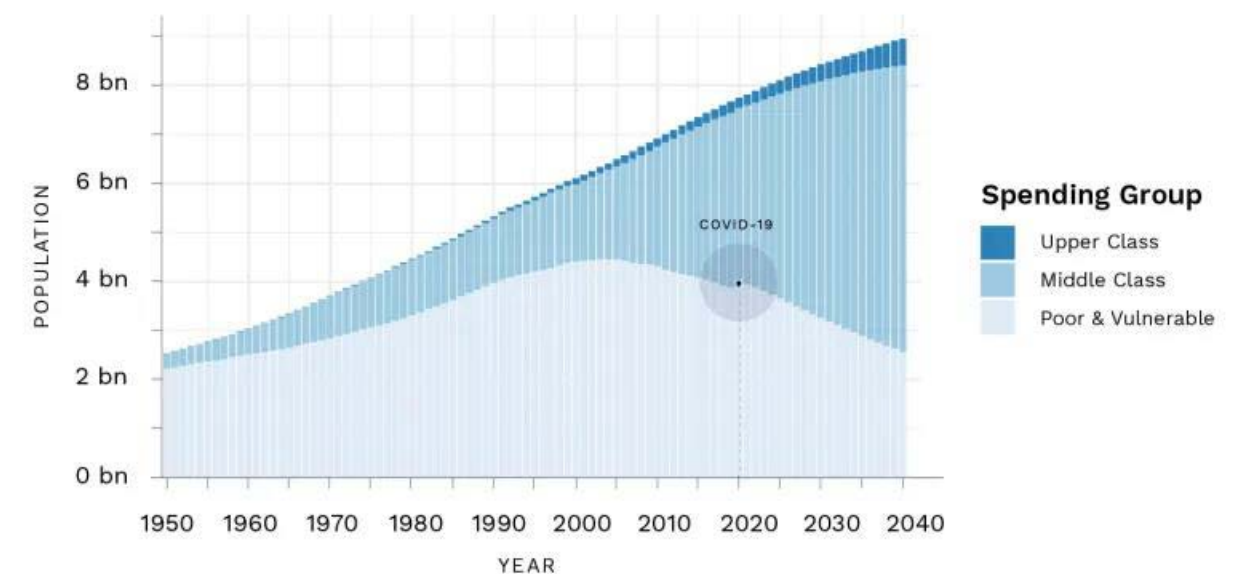
Source: Tsafos (2018)³⁵; Data: International Energy Agency, World Energy Indicators

The data in the chart above show a clear positive correlation between per-capita income and per-capita energy consumption levels for several countries on different continents. This is a cross-section analysis with statistical information referring to the year 2010. This positive correlation is well-known in the specialized literature. Basically, it means that countries with richer (poor) populations consume more (less) electricity per inhabitant. But the causality is twofold. As a population grows richer, its consumption basket diversifies with the inclusion of more goods and services, in addition to access to the purchase of household appliances, small appliances, telephony, and IT equipment. On the other hand, access to energy services, equipment, and electronic

and digital technologies makes it possible to obtain productivity gains, which imply greater wealth generation.

Therefore, projections of high growth rates in energy demand for non-OECD countries stem from the fact that there are also projections that emerging and developing countries will include an important contingent of people in the middle class in the coming decades, highlighting some of the most populous countries in the world, such as China, India, Indonesia, Pakistan, Brazil, Nigeria, Bangladesh, and Mexico. Figure 17 presents a chart with data from the populations of the poor and vulnerable, middle and rich classes. Data includes historical realized values and projected data through 2040.

FIGURE 17. GLOBAL MIDDLE-CLASS GROWTH PROJECTION



Source: Fengler & Kharas (2021)³⁶; Data: World Data Lab's MarketPro, 2021

According to the projections in figure 17, in the year 2040, the global middle class will be substantially larger than the world's poor and vulnerable class. This means that even if we make great technological advances in the production of more energy-efficient goods and services, the growth of the middle class will be very large in a very short period of time. In this sense, it seems unlikely that we will envision a set of compensatory effects of equal proportion in the energy demand economy.

Personal, family and residential consumption will not be the only ones to push for greater energy demand. The manufacturing industry and the provision of various services have greatly intensified the use of automation technologies, in addition to digitization, tokenization, accumulation, mining, and database manipulation processes, as well as the development and training of

machine learning. In fact, industrial production is consuming more and more energy and the trend is that the energy “embarked” per dollar produced continues to increase.

All these technological advances consume a lot of energy and are a source of concern for academics, governments, activists, and the companies directly involved with such processes, including providers of cloud computing services, developers, and software and data engineers. On the other hand, the growing automation and digitization of processes and data usage is increasing the dependence of the manufacturing industry on the provision of abundant, cheap, and, above all, safe energy. In this sense, energy is becoming a determining element of industrial competitiveness, whether in terms of the amount consumed, the price, and the guarantee of delivery.

³⁵ Tsafos (2018). “Energy and Growth: Exploring a Nuanced Relationship”. Center for Strategic & International Studies. See: <https://www.csis.org/analysis/energy-and-growth-exploring-nuanced-relationship>

³⁶ Fengler & Kharas (2021). “A long-term view of COVID-19’s impact on the rise of the global consumer class”. The Brookings Institution.

Barnett et al. (2017)³⁷ developed a table with energy consumption parameters for different types of robots and applications. According to the authors, an industrial robot consumes, on average, 21,915 kWh/year. The average consumption of a robot for professional purposes (surgery and health, rescue and security, inspection, maintenance, and cleaning) is 2,805 kWh/year. For the purpose of comparison, the average residential electricity consumption in Brazil is approximately 2,000 kWh/year.

It must be considered that the "commoditization" of sophisticated productive equipment such as robots, artificial intelligence systems, and digitization of

processes and production has even taken hold in developing countries and is transforming production techniques where there is an abundance of labor, such a way that industrial energy consumption should grow disproportionately in countries outside the OECD group.

The eventual transfer under Powershoring of industrial plants currently located in China, Europe, and elsewhere to LAC will increase the demand for green energy, while freeing up consumption of gray energy in the countries of origin, thus accelerating decarbonization in the globe. In this sense, LAC would have to prepare for the increased demand for green and safe energy.

CLIMATE RISKS AND EXTREME EVENTS

Some industries around the world already suffer from energy insecurity, including recurrent episodes of energy rationing and electricity supply discontinuities arising from different causes, including climate events such as extreme heat waves and floods. Such episodes include, for example, the suspension of production or closure of factories for electronics, semiconductors, solar panels, and batteries in the Chinese province of Sichuan and of textile industries in Pakistan (Keefe, 2022),³⁸ or the suspension of industrial production in parts of California due to drought, or atomic energy production in France due to low water flow in rivers.

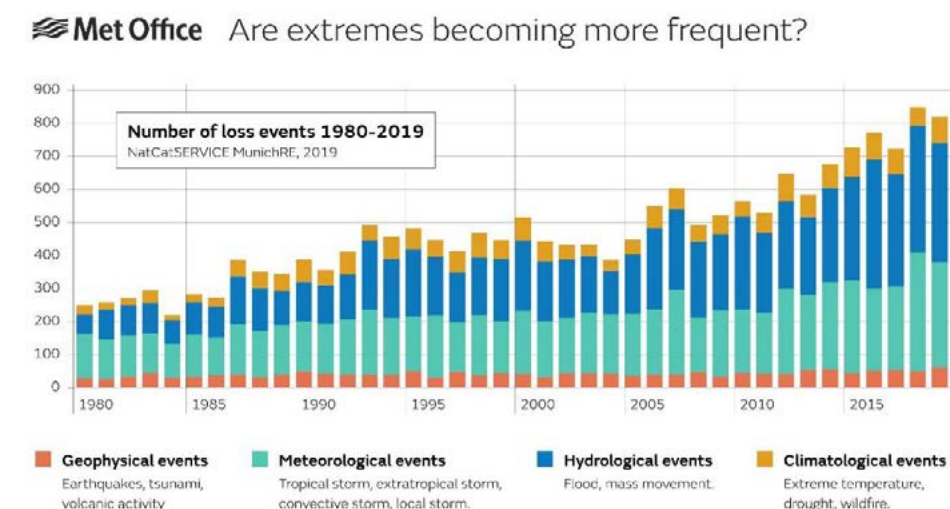
As already discussed, the pursuit of profit maximization driven by a strategy to minimize operating costs has led many companies and sectors to concentrate their operations in a single region of the globe. Economies of scale, scope, and economic agglomeration ensured the success of this location criterion with the Offshoring strategy. But while it provides economies of scale and scope, economic concentration also implies greater risks. Geographical concentration risks used to receive greater attention from bank credit risk managers as well as

professionals in actuarial risk management for insurers and reinsurers, in addition to portfolio managers' geographically diversified asset selection techniques. In summary, the issue of geographic concentration used to receive greater attention from risk managers at financial institutions.

The implications of the COVID-19 pandemic contributed to industrial companies starting to reassess with more attention their strategies for locating production plants. After all, strategies based on cost minimization increased logistical risks and production interruptions, resulting in widespread shortages of machinery, equipment, parts, pieces, products, and inputs. There are several cases of companies that lost market share due to a reduction or suspension of production due to the non-provision of inputs or logistical breakdowns.

A pandemic, for example, is considered a "tail event", that is, the probability of occurrence is low, as well as extreme climate events. The problem is that the effects of climate change have led to an increase in the number of extreme events over the last few decades, as can be seen in the chart in figure 18.

FIGURE 18. NUMBER OF EXTREME EVENTS 1980-2019, WORLD

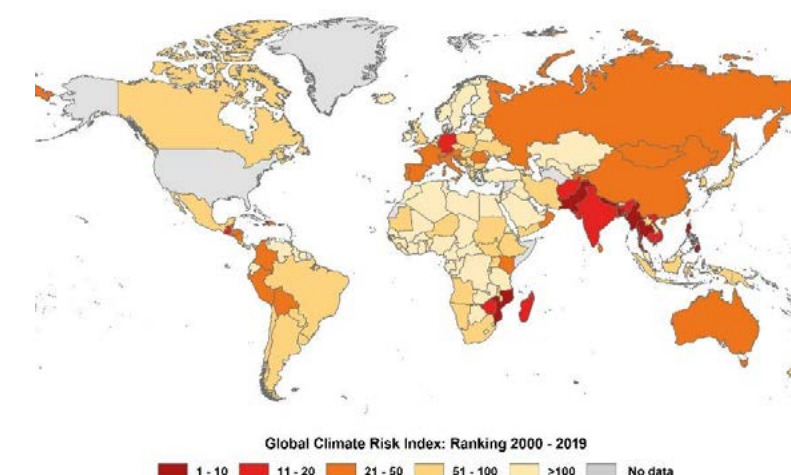


Source: Met Office Reino Unido, Data: Munich RE³⁹

Such events have resulted in recurrent episodes of energy rationing and interruptions in the supply of electricity, suspension of production, or closure of plants. Evidently, some regions are more likely to incur events of this nature than others. However, it is not possible to state that there is any region of the globe free of such risks,

as can be seen in the map in Figure 19, which presents the climate risk indices for the different countries of the world, based on a vector of indicators that include the number of extreme events, pecuniary losses, and human losses (both in total and per capita values) in each of these countries in the period 2000-2019.

FIGURE 19. GLOBAL CLIMATE RISK INDEX, 2000-2019



Source: Eckstein and others (2021)⁴⁰

³⁷ Barnett e outros (2017). "Direct and Indirect Impacts of Robots on Future Electricity Load". ACEEE Summer Study on Energy Efficiency in Industry.

³⁸ Keefe, Bob (2022). "The price of energy insecurity". Finance & Development, International Monetary Fund. See: <https://www.imf.org/en/Publications/fandd/issues/2022/12/POV-the-price-of-energy-insecurity-keefe>

³⁹ See: <https://www.metoffice.gov.uk/binaries/content/gallery/metofficegovuk/images/weather/learn-about/climate/frequency-of-extremes-graph--1980-2019.jpg/frequency-of-extremes-graph--1980-2019.jpg/metofficegovuk%3Axxlarge>

⁴⁰ Eckstein and others (2021). "Global Climate Risk Index 2021: Who Suffers Most from Extreme Weather Events?". Germanwatch.org.: Berlin, Germany.

The countries with the ten highest climate risk index, CRI - which means greater intensity of adverse effects in the period analyzed - were: 1- Puerto Rico (7.17); 2 - Myanmar (10.00); 3 - Haiti (13.67); 4 - Philippines (18.17); 5 - Mozambique (25.83); 6 - Bahamas (27.67); 7 - Bangladesh (28.33); 8 - Pakistan (29.00); 9 - Thailand (29.83); 10 - Nepal (31.33). As for the countries selected in this report, the CRI was: 81 - Brazil (79.50); 83 - Chile

(81.33); 38 - Colombia (54.83); 96 - Uruguay (89.83)⁴¹. The fact that the LAC countries selected here have relatively less human and pecuniary losses (% of GDP) due to climate events in the period 2000-2019 does not necessarily imply that the coming years will bring similar performance. However, the available data provide the most reliable results possible for measuring risks of this nature.

ENERGY AND CLIMATE CHANGE GEOPOLITICS

China-US competition

There is consensus among researchers that US geopolitical hegemony has been challenged by China's economic rise. In fact, the Chinese economy is already larger than the US in terms of GDP-PPS (or GDP Purchasing Power Parity)⁴². In this report, we work with the dimensions proposed by Klement (2021)⁴³ to understand this competition, namely: data and cybersecurity, energy and natural resources, and climate change. However, we prioritize discussions related to the dimensions of energy and natural resources, and climate change.

The first point to be highlighted is that US-China relations have historically been characterized by great complexity. Such relationships cannot be seen through terms like "allies" or "enemies". These countries are mutually identified as potential competitors in many dimensions, therefore, they maintain cooperation in specific areas. During the Cold War, both maintained a strategic political alliance, in opposition to the Soviet regime, once China-Soviet Union relations reached a high degree of wear and tear at the end of the 1960s as a result of border conflicts and growing conflicts driven by the Chinese Cultural Revolution⁴⁴.

At the end of the Cold War, with the dissolution of the Soviet Union, the US began to lose interest in the political-strategic alliance with China and in the heterodoxy of development models in the Asian region (Visentini, 2021)⁴⁵. This disinterest and end of tolerance

to development models such as those advocated by the "Asian Tigers" and "Dragon" would gain strength and visibility with the support and sponsorship of the US Treasury Department for the Washington Consensus, which would contribute decisively to what would be known as the third wave of globalization.

It turns out that one of the economies that most benefited from the third wave of globalization was precisely China, especially after being admitted as the 143rd member of the World Trade Organization (WTO) in 2001. Since then, the volume of trade between the two countries has grown considerably, as has the accumulation of US trade deficits with the Chinese partner, with emphasis on trade in manufactured goods.

The implications for US manufacturing employment were severe. Kimball and Scott⁴⁶ suggest that in the period between 2001 and 2013, the US industry lost or displaced 2.4 million industrial jobs as a result of bilateral China-US trade. The loss of industrial jobs was not limited to the US economy. Several Western economies have suffered such an impact, including Europe and Brazil. The loss of industrial jobs would have resulted, among other things, from a movement of great reallocation of productive industrial plants to China, but also to India and Malaysia, which became the most important destinations of the Offshoring strategy, as already discussed earlier.

⁴¹ Os números entre parênteses referem-se aos valores dos índices CRI e os números fora dos parênteses referem-se às posições no Ranking CRI.

⁴² IMF (2021). "World Economic Outlook: Managing Divergent Recoveries". World Economic Outlook. International Monetary Fund: Washington, DC.

⁴³ Klement, Joachim (2021). "Geo-Economics: The Interplay Between Geopolitics, Economics, and Investments". CFA Institute Research Foundation.

⁴⁴ Kuisong, Yang (2000). "The Sino-Soviet Border Clash of 1969: From Zhenbao Island to Sino-American Rapprochement". Cold War History. 1 (1): 21-52.

⁴⁵ Visentini, Paulo (2021). "A Nova Geopolítica do Século XXI: O Ressurgimento das Potências Terrestres na Eurásia". Em A Geopolítica da Energia do Século XXI. Guilherme Góes (Org). Editora Sinergia: Rio de Janeiro/RJ.

⁴⁶ Kimball, Will e Scott, Robert (2014). "China Trade, Outsourcing and Jobs". Economic Policy Institute, Briefing Paper #385.

The global number of exports and imports as a percentage of GDP would grow from approximately 40% in 1990 to 60% in 2008 when this trajectory

was abruptly interrupted by the effects of the Great Recession (Subprime Crisis), as can be seen in Figure 20.

FIGURE 20. SHARE OF EXPORTS AND IMPORTS IN GLOBAL GDP



Source: Prado (2018)⁴⁷, Data: Word Bank

It is important to note that a good part of the conversion of China into the "factory of the world" was due to foreign companies, notably North American, which produced and exported from that country. In fact, production from Asia was functional for US interests, either because it increased the international competitiveness of its industry, or because it made it possible to import manufactured goods at low prices, including textiles, shoes and toys, and other products from popular consumption, which would provide political support and feedback to the Offshoring economic model.

But the Offshoring model has fostered growing economic, trade, and investment interdependence between the US and China. On this journey, China would accumulate critical industrial mass and business knowledge and would consolidate itself in the 2000s as the biggest destination for foreign direct investment, but no longer just because of low labor costs, but, and above all, because of the constitution of a rich and dynamic industrial, technological and innovation ecosystem and increasingly composed of sophisticated Chinese and Asian companies.

The initial benefits of Offshoring would not last forever, nor would it be politically neutral. China's growth and the

economic stagnation of former industrial regions in the US and Europe would give rise to growing controversy about the benefits of that strategy. It was in this context that, during the Administration of President Donald Trump (2017-2021), concepts such as Nearshoring and Reshoring were developed, which preach the supposed virtues of bringing "back home" North American industrial plants operating in Asia. But the tension was already brewing even earlier. In fact, during the Administration of President Barack Obama (2009-2017), the White House published several documents on the benefits of an active industrial policy in a context of increasing strategic complexity and concentration of markets and the need to protect jobs.

The Offshoring strategy was central to strengthening the Chinese economy, to the point of placing it in conditions of economic and geopolitical competition with the US. However, it would not be just the Offshoring strategy that would project the Chinese economy toward the next steps in that dispute. As already discussed, the fourth and fifth waves of localization strategies were characterized by Offshore-to-Onshore and Offshore-to-Nearshore movements, respectively. The shortage problems arising from the COVID-19 pandemic would reinforce discussions around the Reshoring strategy, or the return of industries to their country of origin.

⁴⁷ Prado, Eleutério (2018). "Três ondas da globalização: uma explicação estrutural". Economia e Complexidade. See: <https://eleuterioprado.blog/2018/09/01/tres-ondas-da-globalizacao/>

One of the key episodes in the competition involving the two countries took place in March 2018, when the US government announced that it had suffered from unfair trade practices by China and imposed tariffs in the amount of US\$50 billion on Chinese imports. In July of the same year, the Beijing government retaliated, announcing the imposition of 25% tariffs on 545 products imported from the USA. The following year, in August 2019, the US Treasury Department formally filed an accusation with the International Monetary Fund that the Chinese government was manipulating the value of its currency, the Yuan⁴⁸, in an event that became known as the “Currency War”.

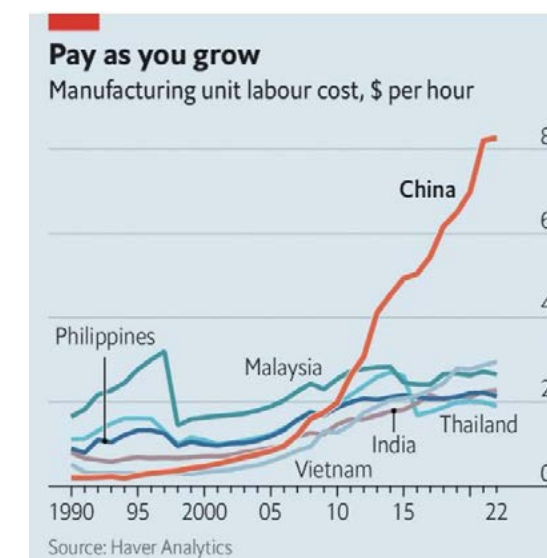
China's stance throughout that period was not limited to trade disputes. The country has sought to expand its area of political influence, including in regions under US influence and that of its allies. In the case of the African continent, its influence takes place through investments, financial aid, and infrastructure projects. In the case of LAC, influence has been boosted in recent years by the “Covid-19 Diplomacy” or “Mask Diplomacy”, which consisted of supplying and donating masks, respirators, protective equipment, and vaccines. Additionally, China has become the main trade partner of most South American economies, in addition to already having significant investment stocks in renewable energy projects, infrastructure, and other sectors. In terms of flows, China is already the main investor in several countries in the region. Finally, China has moved closer to Russia.

Recent geopolitical conflicts are spurring discussions around Reshoring strategy, and also Friendshoring,

or location-based around geopolitical alliances. On the other hand, the Offshoring strategy would also be under review due to microeconomic and demographic factors associated with costs. Figure 21 shows that wages in China, as well as in other economies benefiting from Offshoring, have consistently risen, reducing the attractiveness of the strategy for the production of industrial goods with low added value and which faces broad international competition.

The US Department of Energy regularly publishes the Critical Material Strategy report, which evaluates the criticality of materials used in low-carbon clean technology components, such as rare earth metals, neodymium, yttrium, and others. The report also assesses the criticality of materials used in the manufacture of mass consumer products, smartphones, and components, such as the chemical element Indium (In). The main producer of these materials is China, with 90% of the supply (Guimarães, 2021). On the other hand, part of the US space agency's research efforts, as well as its network of cooperation with private investors in space station missions (such as Elon Musk of SpaceX, Jeff Bezos of Blue Origin, and Richard Branson of Virgin Orbit), seek the economic and technological viability of mining rare earth metals on the Moon, still in this century. The US National Science Foundation monitors and compares the state of scientific and technological development of the two countries in critical sectors and has warned that the American leadership is rapidly diminishing for China, as well as that the Asian country already leads or co-leads sensitive sectors, which has also contributed to explaining the geopolitical tension.

FIGURE 21. HOURLY WAGE TRAJECTORY (US\$) – CHINA, PHILIPPINES, INDIA, MALAYSIA, THAILAND, AND VIETNAM – 1990-2022



Source: The Economist⁴⁹, Haver Analytics

The next step in this reversal in Sino-American relations would come from the North American and European policies of capital controls and exports of goods and services considered critical, such as chips, in addition to the generous subsidy programs and protectionism for the industry, which seems will influence the global order of trade and the geography of investments. Unfortunately, globalization as we know it is coming to an end, and with it many of its benefits, such as middle- and lower-class consumption. The liberal principles that guided the destination of investments lose space and geopolitics and interventions in markets enter the scene.

It is interesting to assess the effective impacts that such measures have brought to the volume of trade between countries, with emphasis on the recent trajectory of demand for US imports of Chinese products. US protectionist measures were implemented in two stages. The first stage took place in July 2018 and imposed a 25% tariff on three lists of Chinese products: List 1, which includes machinery, electrical products, and vehicles; List 2, which includes polymers, plastics, and generators; and List 3, which includes chemicals, food, and metal products. The second stage took place

in September 2019 and imposed a tariff of 7.5% on a fourth list of products, called 4A, which includes other food, other metal products, and clothing.

It was expected that the aforementioned measures would imply a significant destruction of trade (“decoupling”) between the parties. In fact, the immediate impact (2019-2020 biennium) of these measures was a reduction in the aggregate volume of US imports from China. However, since 2021 such volumes have grown substantially and in 2022 reached the same record level as in 2018, the year that preceded the first phase of the increase in rates.

The answer to such a counterintuitive result was developed in detail in a recent paper by the Peterson Institute for International Economics (PIIE), authored by Chad P. Brown⁵⁰. To this end, Brown (2023) raised a historical series with annual data on US imports from China and decomposed it into three groups of products: (1) products that did not suffer any tariff increase; (2) products that suffered a 25% rate increase, lists 1, 2 and 3; and (3) products subject to a 7.5% rate increase, list 4A. Data from the historical series broken down into these 3 groups are reported in the chart in Figure 22.

⁴⁸ See: <https://home.treasury.gov/news/press-releases/sm751>

⁴⁹ See: <https://www.economist.com/business/2023/02/20/global-firms-are-eyeing-asian-alternatives-to-chinese-manufacturing>

⁵⁰ Brown, Chad (2023). “US imports from China are both decoupling and reaching new highs. Here’s how”. Peterson Institute for International Economics (PIIE). See: <https://www.piie.com/research/piie-charts/us-imports-china-are-both-decoupling-and-reaching-new-highs-heres-how>

FIGURE 22. TRAJECTORY OF SEGMENTED IMPORTS BY THE US FROM CHINA, 2017-2022 (VALUES IN MILLIONS OF US\$)



Source: IE, Brown (2023)

The data shows a trajectory of trade destruction and "decoupling" since 2018 for products on lists 1, 2, and 3, which had their tariff rates increased to 25% in July 2018. In the case of products on list 4A, which had their tariff rates increased to 7.5% in September 2019, the scenario is one of a stagnant trajectory. Finally, the amount of trade involving products that did not undergo any tariff increases has shown a strongly upward trajectory since 2020, strong enough to compensate for the reductions incurred in the trade of products on lists 1, 2, and 3.

Nor is the geopolitical dispute painless for Chinese, North American, and European private businesses. As political issues and untimely government interventions affect established contracts and private interests, uncertainties are created. Uncertainty heightens the perception of risk and casts doubt on the economic viability of investment projects. Geopolitical intervention in business affects both sides of the Pacific: American business in China, and Chinese business in the US. However, as capital is fungible and always seeks the best business opportunities, to mitigate the possible deleterious effects of "Made in China" protectionism, Chinese companies are already considering moving industrial plants to other parts of the globe, including LAC, to, from there, and with a "Made in ...", to have

easy access to markets of interest, including the North American, Canadian and European ones. On the other hand, geopolitical tension also affects the image of North American and European products and services and helps to explain the growing penetration of Chinese products in several markets. In this way, the high political temperature is harmful for business.

Europe

Europe is witnessing a growing number of industrial companies struggling to overcome the serious energy price and supply crisis, which is associated, at least in part, with the strong dependence on imports of the input. The crisis was already on the horizon even before the Ukrainian War, but it has accelerated since then. While several companies are reducing production, others, especially small and medium-sized ones, are closing their doors, and many others are laying off employees and relocating part of their operations abroad as a way of dealing with the situation.

According to Kirkegaard (2023),⁵¹ current natural gas prices in Europe have fallen to levels last seen in late 2021, just before the Russian invasion. The EU's wholesale Benchmark Title Transfer Facility (TTF)

natural gas price was steady at €15/megawatt until the COVID-19 pandemic drove the price down, followed by the price surge last year when it reached around €350/megawatt. Prices fell to just below €60 during early 2023, with the forward curve projected to be relatively flat between €60 to €70/megawatt by the end of winter 2025, but a level well above the recent historical pattern prevalent in Europe.

Surveys point to the growing interest of local companies in transferring plants to other countries. Some analysts already consider an "accelerated deindustrialization of Europe"⁵². The combination of negative factors in the energy sector affects contracts and businesses, with deleterious implications for companies' market share. Energy has definitely ceased to be an additional cost item to become a critical factor in industrial operations. It is likely that the relocation movement will continue to advance in the coming years, especially among companies in sectors that consume energy intensively in the production process.

The European Commission has already been addressing the industrial policy issue for years with the publication of several very influential White Papers.⁵³ More recently, it began to implement those policies justified, among others, in the defense of strategic interests and the need to promote the digital economy, the energy transition, and the sustainability agenda.⁵⁴ The war in Ukraine and the pandemic combined to justify those market intervention policies, industrial policies, and the promotion of the Reshoring strategy. In both cases, the policy is anchored in substantial budgetary resources, discrimination, and protectionism.

But the European theme also involves climate policy, and the region has been the protagonist of the main environmental compliance initiatives. Its decarbonization goals are ambitious and aim to become the first continent with carbon neutrality by 2050, as recommended by its European Ecological Pact 2019-2024, the European Green Deal. In general terms, this initiative can be summarized in the terms below:

"The European Commission has adopted a set of legislative proposals with the aim of making EU climate, energy, transport, and tax policies adequate to achieve a reduction in net greenhouse gas emissions of at least 55% by 2030 compared to 1990 levels." (European Commission)⁵⁵

We cannot forget that carbonization generates negative externalities and that we already have organized markets capable of pricing such externalities through Carbon Offset Prices. These compensatory credits give their holders the right to pollute, that is, the regulatory agencies for environmental protection authorize the holders of these credits to emit sulfur dioxide, carbon monoxide, and other polluting gases. The problem is that, depending on the prospective scenario for such markets, the price for carbon offsetting could grow by up to 3,000% by the year 2030 (Bloomberg, 2022)⁵⁶ with broad implications for the competitiveness of European companies and their interest in seeking production alternatives in places where the energy matrix is already green or almost green, as is the case in several LAC countries.

Returning to the geopolitical discussion, it should be noted that a set of circumstances has hampered

⁵² Erken, Hugo & van Es, Frank (2023). "The Economic Impact of European De-industrialization: Geopolitics Takes Center Stage". Rabobank Research. See: <https://www.rabobank.com/knowledge/q011349684-the-economic-impact-of-european-de-industrialization-geopolitics-takes-center-stage>

⁵³ A summary of this discussion is available at: European Parliament (2022). "General principles of EU industrial policy". Fact Sheets on the European Union, September I, 2022. See: <https://www.europarl.europa.eu/factsheets/en/sheet/61/general-principles-of-eu-industrial-policy>

⁵⁴ The following excerpt from the European Commission's (1/2/2023) "Green Deal Industrial Plan" is enlightening: "In the next few years, the economic shape of the net-zero age will be firmly set. New markets will have been created, breakthrough clean technologies will have been innovated, developed, and brought to market, and our energy systems transformed. Therefore, those who invest first and faster today will secure their place in this new economy and create jobs for a newly skilled workforce, rejuvenate industrial manufacturing bases, lower costs for people and businesses and be in a prime position to support other parts of the world to decarbonize their own economies. The scale of the opportunity for European industry puts this need in sharp focus. The International Energy Agency estimates that the global market for key mass-manufactured clean energy technologies will be worth around USD 650 billion a year by 2030 (approximately EUR 600 billion) – more than three times today's level. The related energy manufacturing jobs could more than double in the same time period. The net-zero industry globally is growing strongly, to the extent of demand sometimes outpacing supply." Source: https://commission.europa.eu/system/files/2023-02/COM_2023_62_2_EN_ACT_A%20Green%20Deal%20Industrial%20Plan%20for%20the%20Net-Zero%20Age.pdf

⁵⁵ European Commission (2021). "European Green Deal". See: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_pt

⁵⁶ Bloomberg (2022). "Compensações de carbono: preço pode subir 3.000% até 2029 sob regras mais rígidas". See: <https://www.bloomberg.com.br/blog/compensacoes-de-carbono-preco-pode-subir-3-000-ate-2029-sob-regras-mais-rigidas/>

⁵¹ Kirkegaard, J.F. (2023). "Europe's energy problem is now climate change, nor Russia". Petersen Institute for International Economics, Washington, DC.

European pretensions to lead the energy transition at the expected pace and become the first continent with carbon neutrality by 2050. One of them is associated with the fact that there is no consensus in Europe regarding the classification of nuclear energy as sustainable energy, with Germany being the main opponent of nuclear energy as a sustainable source, including deactivating almost all of its nuclear plants (Nienaber, 2022)⁵⁷. On the other hand, countries like China and Russia are working aggressively to become world leaders in nuclear technology.

According to Guimarães (2021), “the policy difference for nuclear energy in Germany and China is not driven by the economy, but by public perception”. This point is central to the discussion on energy transition, since, according to the same author, “public acceptance of different low-carbon technologies often plays a determining role as to which one is chosen”.

The economic recovery after the COVID-19 pandemic increased the demand for energy on the continent, at the same time that the war between Ukraine and Russia broke out, a country that until then supplied 40% of the natural gas consumed in Europe. The conflict is especially sensitive for Europeans, and for several reasons.

The first is that the annexation of Crimea by Russia, in March 2014, had already caused diplomatic strain between the parties. The second reason is that Ukraine is considered an allied economy of the European Union, and the country even applied for candidate membership status (application granted by the European Council in June 2022). The third reason is that Ukraine is a transit country for Russian gas pipelines. Approximately 40% of Russian gas sold to Europe transits through pipelines that cross Ukraine (Frontliner, 2022).⁵⁸ Additionally, other adverse events have contributed

to the energy crisis in the region, as highlighted by Chaves (2022):

“In addition to the question of demand, other external and geopolitical factors, such as the emergence of extreme climate events, the depletion of regional natural gas stocks, the reduction in wind speed in some regions, and interruptions in the supply chain, have been consolidating a scenario of a major energy crisis in Europe”. (Chaves, 2022)

This set of adversities severely impacted electricity prices on the continent. In Germany, for example, the market price of energy grew by 140% between January and October 2021 (Bateson, 2021)⁵⁹ and therefore even before the war. Such circumstances have motivated the country to postpone the decommissioning of its last three nuclear power plants in operation (DW, 2022)⁶⁰.

Although this set of adversities has contributed to the European continent accelerating its energy transition even further, the fact is that the costs of adapting to shocks and accelerating the transition have been quite high. This brings a set of challenges for the local industry, which has been faced with rising energy costs, insecurity in energy supply, and, finally, uncertainty regarding the trajectory of carbon offset prices.

In this sense, it seems more than reasonable to consider that companies on the continent can benefit from the generation of economic value from the Powershoring strategy, especially industrial sectors with greater carbon footprints and high energy consumption, such as chemicals, fertilizers, pig iron, steel, non-ferrous metals, machinery and equipment, transport equipment, electrical equipment, plastics, food, glass, pulp, and paper, among many others (Ritchie et al., 2020).⁶¹

Regions with Immediate Interest in Powershoring

Our understanding is that Europe, China, and the US would be the regions with the most immediate interests in implementing the Powershoring strategy in LAC. Europe, for the reasons given in the previous section. Additionally, it must be considered that LAC and Europe already have a long history and tradition of partnerships and sharing of visions and values that would further justify the strengthening of the transatlantic relationship, which could advance on the already successful experiences, such as the high stocks of direct investment that Europe already has in the region. Furthermore, LAC is relatively close to Europe. Powershoring would therefore be a kind of “bridge over the Atlantic”, which would serve converging interests.

China's interest would reside, among others, in circumventing discrimination against “Made in China”

products; circumventing the problem of protectionism associated with the carbon footprint of the production chain, and benefiting from trade agreements that LAC countries already have with markets of Chinese interest. China already has a substantial and growing commercial presence in the region, has developed knowledge and partnerships based on these relationships, and could contribute new investments, considering the significant amounts it already has in several LAC countries.

In the case of the US, the tension with China and the promotion of Nearshoring in LAC are already beginning to bear fruit. According to the IDB, Nearshoring would have the potential to generate US\$78 billion in additional exports for LAC, with Mexico the biggest beneficiary⁶². The map in Figure 23 details the estimated amounts by LAC country.⁶³

⁵⁷ Nienaber, Michael (2022). “Alemanha se opõe a classificar energia nuclear como energia sustentável”. See: <https://www.cnnbrasil.com.br/internacional/alemanha-se-opoe-a-classificar-energia-nuclear-como-energia-sustentavel/>

⁵⁸ Frontliner (2022). “Ucrânia corta fluxo de gás russo para a Europa”. See: <https://www.frontliner.com.br/ucrania-corta-flu-xo-de-gas-russo-para-a-europa/>

⁵⁹ Bateson, Ian (2021). “Os alemães podem mudar de ideia sobre a energia nuclear?”. DW. See: <https://www.dw.com/pt-br/os-alem%C3%A3es-podem-mudar-de-ideia-sobre-a-energia-nuclear/a-59700842>

⁶⁰ DW (2022). “Alemanha adia desativação de suas 3 últimas usinas nucleares”. DW. See: <https://www.dw.com/pt-br/alemanha-adia-desativa%C3%A7%C3%A3o-de-suas-3-%C3%BAltimas-usinas-nucleares/a-63467672>

⁶¹ Ritchie and others (2020) - “CO₂ and Greenhouse Gas Emissions”. OurWorldInData.org. See: <https://ourworldindata.org/co2-and-greenhouse-gas-emissions>

⁶² IDB (2022). “Nearshoring can add annual \$78 bln in exports from Latin America and Caribbean”. New Releases June 07, 2022. See: <https://www.iadb.org/en/news/nearshoring-can-add-annual-78-bln-exports-latin-america-and-caribbean>

⁶³ Although Nearshoring can be quite promising, evidence shows ambiguous situations. This is because most Nearshoring to date has been directed to Mexico, partly due to its proximity to the United States and the free trade agreement with that country. However, there is evidence that production costs and conditions in Mexico are less favorable than in China. In addition, Mexico has a less diverse and sophisticated ecosystem of goods and service providers than China, and many inputs for production are imported from that Asian country. Finally, Mexico faces reliability issues in the provision of energy and has an energy matrix still based on fossil fuels (see “Nearshoring Shift Brings Production Hurdles Closer to Home” - Wall Street Journal 24/4/2023).

FIGURE 23. ESTIMATES OF ADDITIONAL EXPORTS BY NEARSHORING
(OPPORTUNITIES BY LAC COUNTRY)



Source: IDB (2022)

In 2018, China exported US\$543 billion to the US, while LAC exported US\$467 billion. In 2022, those numbers increased to US\$ 526 billion and US\$ 603 billion, that is, LAC is, in fact, already gaining space in the American market. Recent data show a significant increase in the region's exports of machinery and equipment,

and manufactures of wood, aluminum, glass, and medical and chemical instruments, suggesting potential for expansion. Powershoring will be able to leverage this movement, meeting environmental requirements and creating a production protection belt.



POWERSHORING: RISKS AND THREATS

Photo: Adobe Stock

This section addresses risks and threats to the Powershoring strategy in LAC. In general terms, such risks and threats can be divided into two components: external and internal. The risks and threats of an external nature are mostly related to the effects and impacts resulting from the Reshoring strategy anchored in policies of discrimination, protectionism, and generous subsidies for the domestic production of clean and renewable energy in European countries and the US which, as already discussed previously, they do not enjoy the same comparative advantages as LAC.

The risks and threats of an internal nature are related to the way in which some political and business leaders in LAC envisage exploiting the opportunities arising from the region's comparative advantages in the production of clean and renewable energies. In this sense, they defend a primary-exporter model of H2V produced from the renewable energies available in the region. It should be noted that this internal component has a strong correlation and synergy with the external component, since an important objective is the expansion of the Reshoring strategy, mainly in the US, and of protectionism and discrimination, mainly in Europe.⁶⁵

THE RESHORING STRATEGY WITH SUBSIDIES

Characteristics of business strategies for the geographic location of investments and production plants have already been presented. In this section, we highlight the Reshoring strategy, recently advocated especially by the US and Europe. Reshoring can be defined as the return of industrial plants to their country of origin by voluntary decision or by some kind of governmental incentive or political pressure. It is a business decision that can occur with greater or lesser intensity, depending on the set of political issues or economic incentives available to the decision-maker.

The Offshoring strategy has proved to be economically viable and attractive for decades. However, the comparative advantages that supported such a movement lost potency due to the rise in labor costs in the investment destination countries. Additionally, the concentration of production increased logistical risks and production interruptions, resulting in non-isolated episodes of generalized shortages in the supply of machines, equipment, parts, pieces, products, and inputs. However, from the company's perspective, it is not clear that Reshoring is the best or only economically viable alternative to depleting Offshoring. After all, locational strategies of the "winner takes all" type imply

the geographic reconcentration of production, as well as the increase in the risks arising from concentration, as has been learned recently.

It seems to make sense for companies to consider a supra strategy of geographical diversification of production based on different sub-locational strategies, including Offshoring, Reshoring, and Powershoring. However, there seems to be an effort by developed economies to make Reshoring the hegemonic locational strategy, with the reconcentration of industrial production, but now in some parts of the US and Europe.

The justifications used for reconcentration could be tentatively classified into three groups. The first one is associated with geopolitical issues, a subject already addressed previously. The second one is associated with business. In fact, the International Energy Agency predicts that annual investments in the energy sector of at least US\$ 4 trillion will be needed to achieve carbon neutrality. Still, according to BloombergNEF, another US\$ 21 trillion in investments will be needed in transmission lines by 2050 so that the net-zero policy can be achieved. All of this makes climate change the biggest and most potent area of political influence and

⁶⁴ One of the biggest risks for the LAC is associated with the certification and standardization agenda (for example, in H2V and contracting models), which are typically imposed by the United States and/or Europe. This is because certifications can be used to direct the course of the climate change industry, the distribution of risks, the role each country can play, and capital flows. Aware of this, the LAC should defend its interests and promote coordination to optimize the benefits of Powershoring and adjacent areas, such as the carbon market.

a source of business, wealth, and job generation in the coming decades. And the third one is the return of active industrial policies to the center of US and European public policy.

The challenges of the energy transition and the ambitious decarbonization targets make Reshoring a controversial strategy for at least two reasons: the very risk of geographic concentration of industrial production and the absence of satisfactory comparative advantages in the joint and complementary production of different clean and renewable energies.

There is no doubt that the US and Europe have a unique, valuable, and sophisticated set of tangible strategic assets (physical infrastructure, natural resources, and geographic location) and intangible assets (sophisticated institutions and markets and human and intellectual capital). However, the production of clean and renewable energies is definitely not one of them, at least in the foreseeable horizon, long enough to meet the challenges of the energy transition and the decarbonization targets of the Paris Agreement.

According to BloombergNEF estimates, by 2050, approximately 50% of the electricity produced in the world will be low-carbon and renewable⁶⁵. In this scenario, it is necessary to consider the opportunities arising from the potential for H2V production at competitive prices, made possible by the low costs of combined production of wind and solar energy in some regions of the planet. As already mentioned, the expectation is that, in 2050, countries such as China, Chile, Brazil, Morocco, and Colombia will be among the most competitive in the production and sale of H2V. This point is addressed here to reinforce and clarify the argument about the obstacles to establishing Reshoring as a permanent strategy.

The US and Europe have designed programs to stimulate the local production of clean and renewable energies, as well as the production of related equipment, such as photovoltaic panels, wind turbines, electrolyzers, and others, which will benefit from very generous government subsidies and with discrimination and protectionism. Such initiatives are antagonistic to the policies advocated by the Washington Consensus, suggesting that the third wave of globalization has

succumbed to the effects of the Great Recession of 2008 and that national economic and geopolitical interests are capable of imposing limits on the functioning of markets.

The largest initiative so far in this regard is the Inflation Reduction Act of 2022 (IRA), the US, a stimulus package with an amount of US\$ 433 billion, of which US\$ 369 billion is destined to security programs energy, and climate change. In this amount, several types of incentives and subsidies are envisaged, including: (i) tax credits with the objective of reducing the LCOE of renewable energies by up to 60%; (ii) loans for eligible investment projects with maturities of up to 30 years and covering up to 80% of the projects' CAPEX; (iii) availability of grants for strategic projects overseen by the Department of Energy and the Environmental Protection Agency (EPA); and (iv) changes to tax deduction rules for calculating taxable income and bonuses for low-income communities for installing clean energy infrastructure. (LEK, 2022)⁶⁶.

To illustrate the scope of this measure, according to estimates by Credit Suisse (2023)⁶⁷, the current average cost of H2V in the US would be US\$2.82/kg, but with the tax credit of US\$3.00/kg that will be granted by the IRA, the kilo would have a negative value of US\$0.18/kg, a price that excludes returns to hydrogen producers. Solar module cost could be reduced to US\$0.05-0.10/W by 2025-2030 versus the current average unsubsidized cost of US\$0.25-0.30/W. It is estimated that, with the subsidies and incentives, the American production of solar and wind equipment will become the cheapest in the world and that at least 90% of the domestic demand for that equipment will be supplied by the internal chain itself.

As this type of intervention policy has a very high potential to influence markets, as well as the cost and capital structure of companies, it creates a diversion of trade, investment, and employment that, at the end of the day, can have deleterious consequences for other countries, especially for developing countries, and thus delay the transition to a low-carbon economy. The IRA could guarantee the US a strategic leadership position in the emerging market for H2V and derivative products, as it happened in the global LNG market. However, this leadership does not take into account

considerations related to direct and indirect costs, such as energy security, geopolitical issues, exposure to extreme natural risks, the search for international diversification in the location of industrial plants, the possibility of internal political changes, among others, which may affect the sustainability of that leadership. It is estimated that the IRA will create over 9 million jobs in the US by 2030.

Unilateral measures like this thwart the comparative advantages of developing regions with highly competitive conditions to produce green energy and generate sustainable technological solutions and solutions based on nature that have the potential to convert them into natural participants in a comprehensive, resilient, and socially inclusive process of tackling climate change.

Additionally, it should be noted that "the IRA provides subsidies in the form of tax credits and conditions these credits to US-based production and the supply of inputs from North America" (Demertzis, 2023)⁶⁸. Therefore, it has been interpreted as a violation of international trade rules by its European partners and China. There seems to be a consensus that the IRA has the potential to erode the multilateral cooperation system, including serving as a trigger for a "transatlantic race" of subsidies (European Parliament, 2023)⁶⁹. So far, the reaction of the European Union has been pragmatic, including when negotiating with the US government the extension of IRA benefits to European production plants in North American territory,⁷⁰ but this could change soon, according to analysts.

The European Union has announced very ambitious goals for the energy industry and transition, for example: achieving a market share of 40% of the world's green industry; 40% self-sufficiency in supply levels of critical materials; annual production capacity of 30 GW of photovoltaic solar energy; 36 GW of wind energy; and 31 GW of heat and cold pumps. It is not possible to assess to what extent such targets are feasible in a scenario with the incentives provided by the IRA. In the same way, it is not possible to rule out the possibility that the IRA really serves as a trigger for a "transatlantic race" of subsidies.



According to BloombergNEF estimates, by 2050, approximately 50% of the electricity produced in the world will be low-carbon and renewable

Europe, on the other hand, has taken strong action in the regulatory and normative field, in addition to subsidies, including the EU Green Deal, RePowerEU, and the Carbon Border Adjustment Mechanism – CBAM.⁷¹ CBAM requires most EU carbon-intensive imports to incur carbon taxes comparable to those of companies in the bloc or pay the equivalent of a carbon-based tariff, which is likely to have a major trade impact for other countries, a measure that is also seen as potentially objectionable within the framework of the WTO. In addition to an eventual subsidy plan along the lines of the IRA that would be under consideration, Europe created, at the end of 2022, the European Hydrogen Bank, with the purpose of assuming risks and financing the sector's value chain and developing the market and gas production, with a target of 10 million tons.

US and European protectionism, subsidy, and discrimination measures are a tacit acknowledgment of the relatively lower competitiveness in green energy. There is no doubt that the above measures are capable of creating obstacles for Powershoring in LAC. However, as will be discussed below, the benefits and incentives provided by the US and European measures of geographic reconcentration of industrial plants

⁶⁵ See: <https://www.alemdaenergia.engie.com.br/metade-da-energia-eletrica-produzida-em-2050-sera-de-baixo-carbono/>

⁶⁶ LEK (2022). "Inflation Reduction Act 2022 And its effects on clean energy technology". Mimeo.

⁶⁷ Credit Suisse (2023), US Inflation Reduction Act - A Tipping Point In Climate Action.

⁶⁸ Demertzis, Maria (2023). "The EU response to the United States Inflation Reduction Act". Bruegel.org. See: <https://www.bruegel.org/comment/eu-response-united-states-inflation-reduction-act>

⁶⁹ European Parliament (2023). "Question time: Strengthening transatlantic ties in a challenging multilateral world". At the Glance, Plenary – March 1 2023. See: [https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/745667/EPRS_ATA\(2023\)745667_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/745667/EPRS_ATA(2023)745667_EN.pdf)

⁷⁰ See: <https://www.eleconomista.es/energia/noticias/12189735/03/23/La-UE-logra-que-EEUU-trate-por-igual-al-motor-europeo-en-su-plan-de-ayudas.html>

⁷¹ The European Parliament voted in favor of implementing the CBAM on April 18, 2023.

and production chains would not have the power to mitigate risks associated with this same concentration. Additionally, there is no consensus in the specialized literature that tariff, and non-tariff barriers, subsidies, and fiscal incentives can compensate for comparative

disadvantages permanently. Therefore, the risks associated with the effects of those measures should not be overlooked by LAC, just as their benefits and incentives should not be overestimated by taxpayers, companies, and private investors.⁷²

PRIMARY-EXPORTER MODEL OF GREEN HYDROGEN

A second source of risk to the Powershoring strategy in the LAC is domestic. This risk is associated with the fact that some political and business leaders in the region have envisioned exploring local comparative advantages in the production of clean and renewable energies, however, focused on a primary-exporter business model. More specifically, through the low production cost of wind and solar photovoltaic energy as inputs for the production of H2V for export purposes and supplying production plants in Europe and the USA. This is an international commoditization strategy for H2V, as highlighted by researchers from the Hydrogen Laboratory of the State University of Campinas (Canal Solar, 2022)⁷³.

Still, from this perspective, it is believed that Brazil has all the conditions to become one of the largest H2V export hubs in the world. In the words of Nivalde de Castro, professor at the Institute of Economics at the Federal University of Rio de Janeiro and coordinator of the Electric Sector Study Group (Gesel), “we can become the ‘Saudi Arabia’ of hydrogen” (Rodrigues, 2022)⁷⁴. The potential does indeed exist and as already highlighted throughout this report, it is extensive to other economies in the region, including Chile, Colombia, and Uruguay.

The strategy of establishing H2V and green ammonia export hubs in the Southern Hemisphere, with emphasis

on LAC⁷⁵ and the African continent⁷⁶, is especially aligned with the European energy transition agenda, including the EU Green Deal and the EU Hydrogen Strategy (Sadik-Zada, 2021)⁷⁷ - with the ambitious target of importing 10 million tons of H2V by 2030. For this, the EU is signing letters of intent and other instruments expressing interest in imports and working with governments, ports, and companies, and encouraging investments for the production and export of gas to that continent.

There is no doubt that LAC's partnerships with Europe for the development of H2V production and commercialization can lead to mutually beneficial results. In the same way that the creation of hubs for the export of H2V in LAC does not represent a problem per se, as long as other equally important opportunities for the generation of wealth and economic value are not neglected due to a monothematic and primary-export development strategy. As will be highlighted below, there is no lack of reasons to believe that the region's energy potential can and should be exploited based on a development strategy based on greater levels of productive diversification, economic complexity, and agglomeration economies.

In this sense, it would make sense for LAC to consider a “Three-Way Strategy”. The first way consists of

promoting the enabling factors for increasing the production of green, safe, cheap, and abundant energy. The second way consists of promoting the expansion of H2V production at levels that would guarantee scale gains, scope gains, and a drop in the marginal price to face subsidies, tax incentives, and other price intervention instruments in the US and Europe, in addition to gains of learning, knowledge of the business model, formation of national and international partnerships and local production of equipment, in such a way as to convert the region into a great global H2V hub, taking advantage of the immense comparative advantages in green energy, in addition to the great availability of industrial land, water, and favorable geographical position. The third way consists of the priority use of this gas for the promotion of Powershoring, and exporting the surplus.

The strategies of exporting green energy “embedded” in industrial products and exporting crude green energy are complementary, although they are not temporally synchronized. This is because we are still far from achieving safe and economically viable technologies for the maritime transport of H2V in the form of ammonia, as well as equally safe and economical technologies for converting ammonia into H2V for industrial use in the ports of importing countries. So, other things being equal, local use would likely temporally precede large-scale export. To exploit the full potential of the second route, a set of public policies will be needed to enhance the attractiveness of Powershoring in the region, an issue that will be discussed later. Finally, for the third way, a well-articulated and well-conceived industrial policy will be required, one that is economically viable and innovative, an issue that is also addressed below.



A second source of risk to the Powershoring strategy in the LAC is domestic. This risk is associated with the fact that some political and business leaders in the region have envisioned exploring local comparative advantages in the production of clean and renewable energies, however, focused on a primary-exporter business model.

⁷² By providing huge subsidies and protecting and discriminating against production from other places, the IRA and the EU Green Deal may be a threat to the economies of developing and emerging countries, which do not have the same fiscal and regulatory conditions to protect their economies and interests. Similarly, it threatens decarbonization. The issue is especially complex in a context where several of these countries have suffered greatly from the pandemic and face high indebtedness, high inflation, and an economic crisis. For details, see: <https://www.weforum.org/agenda/2023/03/what-do-green-subsides-mean-for-the-future-of-climate-and-trade-099a016307/>

⁷³ Canal Solar (2022). “Hidrogênio verde caminha para ser commodity internacional”. See: <https://canalsolar.com.br/hidrogenio-verde-caminha-para-ser-commodity-internacional/>

⁷⁴ Rodrigues, Robson (2022). “Brazil pode se tornar maior hub de exportação de hidrogênio verde do World”. Um só Planeta: Energia e Ciência. Globo.com. See: <https://umsoplaneta.globo.com/energia/noticia/2022/09/08/Brazil-pode-se-tornar-maior-hub-de-exportacao-de-hidrogenio-verde-do-World.ghtml>

⁷⁵ See: <https://www.dw.com/pt-br/hidrog%C3%AAnio-verde-promete-turbinar-parceria-Brazil-alemanha/a-64599718>

⁷⁶ See: <https://epbr.com.br/uniao-europeia-avanca-em-gasoduto-para-hidrogenio/>

⁷⁷ Sadik-Zada, Elkhani (2021). “Political Economy of Green Hydrogen Rollout: A Global Perspective”. Sustainability. Vol. 13(23), 13464.

POWERSHORING: BUSINESS VALUE PROPOSITION



Photo: Adobe Stock

Latin America's (LA) comparative advantages in producing clean and renewable energy, with energy security at competitive costs, and in a challenging geopolitical scenario of energy transition and climate change, have led to the creation of a new class of assets and opportunities for private investment.

The first set of these assets is related to the exploration of comparative advantages, such as investments in infrastructure, logistics, and construction of wind farms, solar photovoltaic parks, and plants for the production of H2V.

However, we are interested in discussing another set of assets: investments in industrial production plants that can benefit from the geographic proximity of clean and renewable energy sources, in a market where part of the production would be absorbed regionally, and the surplus would be exported at competitive costs and logistical conditions. In other words, it is the Three-Way Strategy discussed earlier.

A question at this point is what would be the reason why an industrial production plant would benefit from the geographical proximity of clean and renewable energy sources. The answer to this question has already been developed. It has been seen that the main clean and renewable energies currently available at competitive costs are intermittent and are not available in an abundant and simultaneous way anywhere on the planet. In reality, few locations on the globe are capable of producing several clean and renewable energies at competitive costs simultaneously and in a complementary way, a fundamental requirement for mitigating the problem of intermittency. It was also seen that the intercontinental transport of clean and renewable energies, such as H2V exports, is a possibility that still faces technological, cost, and safety challenges that have not yet been adequately resolved.

The fact is that the decarbonization targets imposed on economies around the globe imply the emergence of an energy transition. The emergency affects everyone, but the levels of urgency vary considerably from country-to-country and sector-to-sector, depending on several



From this perspective, the Powershoring strategy appears to be a unique opportunity for those investment projects where the costs incurred in delaying the energy transition are growing and disproportionately high.

factors, including the structures of the energy matrices and profiles of installed capacity and electricity generation, in addition to the different exposures to risks from climate events and geopolitical risks.

From this perspective, the Powershoring strategy appears to be a unique opportunity for those investment projects where the costs incurred in delaying the energy transition are growing and disproportionately high. We briefly discuss below how the Powershoring strategy is capable of producing economic value for private investors through risk diversification, greater resilience, and compliance with the environmental, social, and corporate governance (ESG) agendas and the Sustainable Development Goals (SDGs).

RESILIENCE AND RISK DIVERSIFICATION

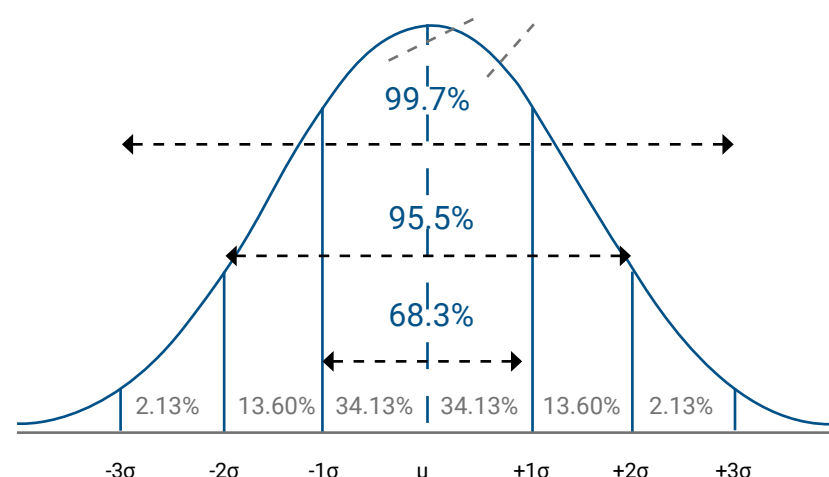
The first business value driver of the Powershoring strategy is risk diversification and economic resilience. To better understand this point, it is necessary to use two fundamental economic and financial concepts: tail risk, ripple effect, and systemic risk.

Tail risk “is associated with rare events, but which can cause extreme losses” (Almeida et al, 2013)⁷⁸. Tail events are also known by the expression “black swans”, a term that associates the occurrence of such events with exceptional situations. The term “tail” is associated with the ends of a normal distribution (Gauss curve), since, having a bell shape, the values of the tails of the distribution have low probabilities of occurrence.

For example, imagine a hypothetical location where

the temperature (T) is normally distributed with a mean of $\mu=25^{\circ}\text{C}$ and standard deviation of $\sigma=8^{\circ}\text{C}$, formally $T\sim N(25^{\circ}\text{C}, 8^{\circ}\text{C})$. The empirical rule of normal distribution (see chart in figure 24) establishes that, within a sample period of 1,000 days, the temperature will vary within the interval between 17°C (mean minus one standard deviation) and 33°C (mean plus one standard deviation) in approximately 683 days. The number of days in which the temperature will vary between 9°C (mean minus two standard deviations) and 41°C (mean plus two standard deviations) is approximately 955 days. Finally, the temperature will vary within the range of 1°C (mean minus three standard deviations) to 49°C (mean plus three standard deviations) in approximately 997 days. In this sense, days on which temperatures below 1°C or above 49°C are considered tail events.

FIGURE 24. NORMAL DISTRIBUTION, EMPIRICAL RULE



Source: <https://dsd.arcos.org.br/estatistica/>

⁷⁸ Almeida, Caio; Vicente, José e Guillen, Osmani (2013). “Estimação não-paramétrica do risco de cauda”. Trabalhos para Discussão 311, Departamento de Estudos e Pesquisas (Depep), Banco Central do Brasil.

⁷⁹ Although black swans (Cygnus atratus) are not so rare in Australia, where they can be found throughout its territory.

Let us now imagine that in this hypothetical location, there is also a hypothetical production plant, projected to operate for 15 years, that is, 5,475 days. Let's imagine that when temperatures become very low (equal to or less than 0°C), the plant's pipes freeze, which would force the plant to be interrupted for repairs. Therefore, when designing the factory, it was known that every 1,000 days of operation there would be the possibility of temperatures exceeding 49°C in 1.5 days, in the same way as the number of days expected for very low temperatures (equal to or less than 0°C) was 1.5 days. Therefore, within the 5,475 days of operation, the plant is projected to be stopped for pipe repair on approximately 8 occasions ($5,475/1000 \times 1.5$). Additionally, assume that each repair takes 7 days of plant outage, thus totaling 56 days of outage for a total of 5,475 days of operation (approximately 1%). Finally, suppose that normalizing production and restoring normal inventory levels require an additional 14 days, adding up to 21 days per event and 168 days in the period (approximately 3%).

Such projections serve as parameters for planning production, managing inventories and operating costs, estimating revenues and their provisions, managing risks, and contingency plans, taking out insurance, hedging contracts, and establishing special contractual clauses with suppliers and customers.

It was seen in the previous sections that the effects of climate change have provided an increase in the number of extreme events over the last few decades (figure 18). As if the increase in the number of events were not enough, it is necessary to add an important ingredient in this scenario: uncertainty.

Our ability to manage risks (contingency plans, provisions, and others) depends on our knowledge of event probability distributions. We know that there is an increase in the number of extreme events, but we are still not able to know exactly where the probability distributions are heading. In our hypothetical example, this means that the number of days when temperatures will exceed 49°C (or drop below 0°C) will exceed 1.5 in 1000. However, we are not able to say how many more days.

It was mentioned that winning locational strategies of the “winner takes all” type implies the geographic concentration of production, as well as the increase in the risks resulting from this concentration. We develop this point here. Let's imagine that the hypothetical location not only hosts the hypothetical production plant but the plants of all its global competitors. We know that over 15 years this link in the production chain will be interrupted approximately 8 times, taking 21 days per event, until



Our ability to manage risks (contingency plans, provisions, and others) depends on our knowledge of event probability distributions

operations are back to normal. As already mentioned, this means that the deleterious effects of tail events would consume approximately 3% of the period, in the form of repairs and productive recomposition. Such costs are far from negligible, but their risks are manageable once we know the event probability distributions.

What happens when we are no longer able to minimally estimate the probabilities of extreme events? Should we be more conservative and scale a “safety cushion” to accommodate the adverse effects of 16 or 24 events every 15 years? Should we maintain the projection of 8 events and accept the risks of non-compliance with contractual clauses, payment of fines, and loss of reputation with customers? Or should we diversify production in different locations, mainly between locations where the periods of greater probability of freezing do not coincide (the summer period in the location of plant A is equivalent to the winter period in the location of plant B, for example)?

Before evaluating answers to these questions, it is necessary to discuss a second fundamental concept: the ripple effect or systemic risk. Dictionaries define the ripple effect as an initial and isolated disturbance in a system, which ends up propagating and reaching an increasingly larger area of that system. Finance dictionaries define systemic risk as the “possibility that an event at the company level could trigger severe instability or collapse an entire industry or economy” (Chen, 2020)⁸⁰.

⁸⁰ Chen, James (2020). “What Is Systemic Risk? Definition in Banking, Causes and Examples”. Investopedia. See: <https://www.investopedia.com/terms/s/systemic-risk.asp>

The specialized literature has used network analysis techniques for a better understanding of systemic risk (ECB, 2010)⁸¹. The aim is to assess how network configurations, concerning density, centrality, and modularity measures, influence the extent of the cascade effect. If the initial disturbance reaches nodes with high centrality (companies, for example) in a very dense network (productive chains, for example), the adverse shock or tail event that originated the process can propagate to all nodes in the network.

Evidently, geographically concentrated productive chains are more likely to represent very dense networks, strongly interconnected through different nodes with great power of centrality. Let us now imagine that the hypothetical location not only hosts the hypothetical production plant and all its global competitors but also the entire production chain, thus constituting a highly dense and interconnected network.

In the event of tail events of a geographic nature - as is the case with the example of temperatures we have been working on so far - the adverse effects of systemic risk will be greatly amplified. Firstly, the adverse effects will be quite pervasive over the entire production chain. Secondly, not only the adverse macro effects will be triggered, which affect the system as a whole (extreme temperatures affect everyone at the same time), but also the idiosyncratic adverse effects (micro) suffered by each of the companies (adverse effects imply specific damage for each of the companies in the production chain). Finally, all problems occur simultaneously.⁸³

It seems clear that in this new hypothetical scenario, the restoration of operational normality in the production chain will far exceed the 21-day estimate for the hypothetical company. It remains clear that the geographic concentration of production provides bonuses (economies of scale and scope) and burdens (more pervasive systemic risks). However, once we know the probability distributions of the tail events, risk management is possible, no matter how costly the amounts involved. In a scenario of uncertainties

regarding the distribution of events, we returned to questions about maintaining a "safety cushion", accepting the risk of contractual defaults or diversifying risks.

As seen in the discussion of waves of production location strategies, corporations seem to be responding to this question by diversifying risks through geographic diversification of production. After all, the concentration of global production, combined with the increase in tail events, have collapsed the operations of several production chains.

The North American and European policy of reconcentrating production seems to go in the opposite direction to this movement. In fact, perhaps very high incentives, benefits, subsidies, discrimination, and protectionism are needed to achieve the objectives of concentrating the world's green industry, since, although the US and Europe have a valuable set of tangible and intangible assets, the joint and complementary production of various clean and renewable energies is definitely not one of them, as seen above.

The central point of the section's discussion is that excessive geographic concentration of industrial production - under conditions of probable growth in the number of tail events and uncertainty about their probability distributions - tends to weaken global production chains, regardless of whether concentration stems from comparative advantages in the production of strategic inputs or generous subsidy systems.

In this sense, Powershoring's value proposition resides in the availability of new investment opportunities and new asset classes that expand the scope for diversifying the private investment portfolio, provide better risk management and imply greater economic resilience of the global value chains. Powershoring presents itself, therefore, as an economically attractive solution to receive part of the industrial production, in a context in which the geographical concentration of production is capable of undermining the resilience of global value chains.

TRIPLE BOTTOM LINE

LAC presents itself as an attractive location to receive industrial investment projects from economic sectors and companies that face challenges or greater emergencies for the completion of a successful energy transition. As already discussed, it is not just a question of ESG compliance or a reputational issue, but also of risk management and environmental liabilities.

Powershoring is a strategy that is highly adherent to the objectives of companies aligned with the concept of the triple bottom line, or sustainability tripod. The triple bottom line is "a business concept that posits that companies should commit to measuring their social and environmental impact - in addition to their financial performance - rather than focusing solely on profit generation or the standard "bottom line" (Miller, 2020)⁸⁴.

A central aspect behind the triple bottom line concept is that discussions around a potential tradeoff between economic outcomes and social and environmental outcomes would be misguided. As already highlighted, a refusal, denial, or postponement of the need to align with the compliance requirements of the ESG agenda could

have severe economic implications for corporations, such as accumulation of environmental liabilities, loss of reputation, and increased risks and costs of raising funds, especially in a world where an ever-increasing portion of the global population (especially consumers) is made up of the middle class, a group that is much less resistant to bearing marginally higher costs to get rid of business models considered misaligned and non-compliant.

Critics of the triple bottom line model "often point to sustainability as a peripheral issue, a fad, greenwashing or an unimportant business issue" (Epstein -Reeves and Weinreb, 2013)⁸⁵. Some of these criticisms do not seem to be completely unfounded, with emphasis on the issue of greenwashing practices, in which complaints against large corporations abound (Koons, 2022)⁸⁶. However, these kinds of criticisms are now well over a decade old and there is no evidence that we would be treating them as a passing fad. Quite the opposite. Governments, consumers, regulators, investors, shareholders, banking institutions, insurance companies, and rating agencies have increasingly pressured companies to pursue triple-bottom-line objectives.



The triple bottom line is "a business concept that posits that companies should commit to measuring their social and environmental impact - in addition to their financial performance - rather than focusing solely on profit generation or the standard "bottom line"

⁸¹ ECB (2010). "Recent Advances in Modelling Systemic Risk Using Network Analysis". European Central Bank. See: <https://www.ecb.europa.eu/pub/pdf/other/modellingsystemicrisk012010en.pdf>

⁸² For a non-exhaustive discussion of measures in social network analysis, see: Disney, Andrew (2020). "Social network analysis 101: centrality measures explained". Cambridge Intelligence. See: <https://cambridge-intelligence.com/keylines-faqs-social-network-analysis/>

⁸³ The concept presented here is also valid for occurrences associated with geopolitical issues and others that may pose risks to the continuity of operations. This theme is especially important for companies with global operations in value chains and that may have a lot to lose with eventual stoppages or reduction of production.

⁸⁴ Miller, Kelsey (2020). "The Triple Bottom Line: What It Is & Why It's Important". Harvard Business School, HBS Online. Business Insights. See: <https://online.hbs.edu/blog/post/what-is-the-triple-bottom-line>

⁸⁵ Epstein-Reeves, James e Weinreb, Ellen (2013). "Michael Porter: coining vital business strategies for sustainability". The Guardian. See: <https://www.theguardian.com/sustainable-business/michael-porter-coined-competitive-advantage>

⁸⁶ Koons, Eric (2022). "Greenwashing Examples 2022: Top 10 Greenwashing Companies". EnergyTrackerAsia. See: <https://energytracker.asia/greenwashing-examples-of-top-companies/>

The fact is that the capitalist system is going through new challenges with the climate emergency (Porter and Kramer, 2011),⁸⁷ which does not mean that it is at risk of extinction, but that it would need to reinvent itself and adapt, like the wide most of the complex adaptive systems we know (Lansing, 2003).⁸⁸

The task of reinvention and adaptation is not a trivial one. When it comes to economics, it is necessary to introduce a systemic, holistic, and pervasive innovation that enables the creation of a platform for new business models that are economically sustainable, replicable, and scalable.

A first proposal in this direction is the Creating Shared Value (CSV) model by Porter and Kramer (2011). The central idea of CSV is summarized by Menghwar and Daood⁸⁹ as “a strategic process through which corporations can solve a social problem that is relevant

to their value chain while obtaining economic profits”.

A second proposal is the Circular Economy Model⁹⁰. The circular economy concept can be summarized as “a production and consumption model that involves sharing, renting, reusing, repairing, refurbishing and recycling existing materials and products for as long as possible” (European Parliament, 2023b),⁹¹ so that the cycle of the product life is extended.

An important point is how the Powershoring strategy aligns with those proposals for generating economic value for corporations. The central point is that the business models that constitute Powershoring's conceptual strategy are being inspired by this paradigm, even in a period of history when it was believed that such models would not be economically viable, sustainable, replicable, and scalable.



Critics of the triple bottom line model “often point to sustainability as a peripheral issue, a fad, greenwashing or an unimportant business issue”

⁸⁷ Porter, Michael e Kramer, Mark (2011). “Creating Shared Value: How to reinvent capitalism—and unleash a wave of innovation and growth”. Harvard Business Review, Jan-Feb 2011.

⁸⁸ Lansing, Stephen (2003). “Complex Adaptive Systems”. Annu. Rev. Anthropol. 2003. 32:183–204.

⁸⁹ Menghwar, Prem e Daood, Antonio (2021). “Creating shared value: A systematic review, synthesis and integrative perspective”. International Journal of Management Reviews. 23 (4): 466–485.

⁹⁰ Boulding, Kenneth (1966). “The economics of the coming Spaceship Earth”. In: Jarrett, H., Ed., Environmental Quality in a Growing Economy, Resources for the Future. Johns Hopkins University Press: Baltimore.

⁹¹ European Parliament (2015). “Circular economy: definition, importance and benefits”. Headlines, Economy – December I 2015. See: <https://www.europarl.europa.eu/news/en/headlines/economy/20151201ST005603/circular-economy-definition-importance-and-benefits>



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POWERSHORING AND MODERN INDUSTRIAL POLICY

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INFORMATION, COORDINATION, AND ECONOMIC COMPLEXITY

Some LAC leaders seem to consider that the main way to exploit the potential of LAC's comparative advantages in the production of clean and renewable energies would be through the specialization and export of H2V. There is no doubt that this business model can be promising, but it should be part of a broader and more ambitious strategy, as we saw above. Although, at first glance, the focus on exporting the green commodity seems attractive from the perspective of specialization based on comparative advantages, the available literature and empirical evidence have shown results that do not corroborate this hypothesis.

Imbs and Wacziarg (2003)⁹², for example, present robust results about a non-monotonic relationship - with a U-shaped curvature - between the degree of sectoral concentration of economies and their per capita income levels. This means that economies that reached high levels of per capita income initially went through a process of productive diversification until they reached a level of sectoral diversification (threshold) and that, from that point of inflection, gains in specialization and concentration become the rule.

This result is robust not only for temporal analyzes (time series) but also for cross-section analyses. Therefore, specialization gains arising from comparative advantages are indeed promising, but not from any stage of economic diversification. There is an inflection point in the concentration (or specialization) curve - which corresponds to the minimum point of the U-curve - in which specialization gains resulting from comparative advantages start to be observed.

A second important aspect to be highlighted from the work of Imbs and Wacziarg (2003) is that no LAC country had reached the average levels of per capita income at which the concentration and productive specialization curves found their inflection points.

In reality, until now, they haven't achieved it either. Therefore, it is worth reassessing whether productive specialization in renewable energies for the purpose of exporting H2V and green ammonia is really the best way for LAC countries to exploit this window of opportunity.

It is reasonable to consider that LAC's comparative advantages in the production of clean and renewable energies should perhaps be used in an integral effort to promote productive diversification, economic complexity, and agglomeration economies. However, this does not imply that the export of H2V should not also be part of the strategy of economic diversification and integration with different global value chains, as proposed by the Three-Way Strategy.

Let's start with the issue of productive diversification. According to Rodrik (2004)⁹³, the diversification of productive structures requires the "discovery" of an economy's cost structure. The fact is that governments and private economic agents often confuse situations involving businesses with high risks with situations involving businesses with unknown risks. It is common for private agents not to invest in certain projects simply because they are unaware of the risks and not because those risks are necessarily high. Let us remember that knowledge of the structure of risks is the first step to mitigate them, especially in the case of higher risks.

The idea of "discovery" proposed by Rodrik (2004) has some parallels with our vocational and professional choices. When the author suggests that "market prices cannot reveal the profitability of allocations of resources that do not yet exist", we can draw a parallel with the fact that we are also unable to assess our vocation for an area of knowledge in which we have not been minimally exposed to. The expression "minimally exposed" is important, as it

⁹² Imbs, Jean and Wacziarg Romain (2003). "Stages of Diversification". American Economic Review, 93 (1): 63-86.

⁹³ Rodrik, Dani (2004). "Industrial Policy for the Twenty-First Century". CEPR Discussion Papers 4767, C.E.P.R. Discussion Papers.

⁹⁴ Hausmann, Ricardo and Rodrik, Dani (2003). "Economic Development as Self-Discovery". Journal of Development Economics, vol. 72, December 2003.

suggests that it is not necessary for us to spend hundreds of hours of specialized training in different areas of knowledge to have clues about our vocations. We usually resort to screening techniques, such as taking vocational tests, participating in lectures, and/or conducting interviews with professionals in the field.

There is no doubt about some degree of randomness in these “discovery” processes. And this also happens in the business world. Hausmann and Rodrik (2003)⁹⁴, for example, provide evidence that countries with identical resources tend to specialize in different sectors. According to the authors, Bangladesh exported (at the time of the research) millions of dollars’ worth of hats, while Pakistan exported tons of soccer balls, but Bangladesh lacked a sports ball industry, while Pakistan lacked a hat industry. Likewise, South Korea was a powerhouse in microwave oven production and export and did not export bicycles, while the reverse pattern was found in Taiwan. As suggested by the authors, it would be impossible to attribute such patterns to the notion of comparative advantage.

For this report, the idea of Powershoring can serve as a way to reduce the randomness of this “discovery” process associated with productive diversification. This means that some productive activities tend to be attracted by the comparative advantages of Powershoring. This situation involves activities whose access to a secure system of clean, renewable, and competitive energy supply constitutes a fundamental driver of value creation for the activity. In these cases, there is clarity about the prices, costs, and risks involved, so the net operating result (NOPAT) of these investments tends to fully remunerate the capital costs (Equity and Debt), to provide economic value (EVA>0). Likewise, Powershoring can also serve as a way to reduce randomness in this “discovery” process by identifying segments that tend to present projects that are known to be unfeasible (EVA<0), under any conditions.

Moving economic diversity efforts forward from the head start of Powershoring is a less obvious task. Exploring the vertical integration of chains with known viable nodes is an obvious answer. However, in the absence

of relevant market information, establishing which activities to prioritize (and how to prioritize them) is a less trivial answer. But Hidalgo and Hausmann’s (2009)⁹⁵ notion of economic complexity can help in this task.

So that we can clearly understand the notion of economic complexity, we resort to an analogy commonly used for this purpose. Suppose that each productive technical knowledge acquired by an economy constitutes a letter that, in turn, can be used in the construction of words (World Economic Forum, 2019)⁹⁶. The more letters (productive technical knowledge) an economy acquires, the greater its ability to produce words (produce different activities). However, some vocabulary letters are capable of producing more words than others. For example, in Iberian languages, vowels are fundamental to building words. In the Portuguese language, there are no words without vowels.

Let us imagine, now, that an event (Powershoring, for example) provides a given economy with obtaining the letters (productive technical knowledge) A and C. If the objective is to maximize the ability to construct words (different products and services) from the available letters, the search to obtain a third letter should not be random. It is clear that a third letter, M or S, for example, would be much more valuable than a letter X or Y. Therefore, the notion of economic complexity also contributes to the reduction of randomness in the process of productive diversification.

Defining whether the immediate search for productive technical knowledge M or S is preferable to X or Y is a task for Engineering. Evaluating whether the benefits, costs, and risks incurred in the acquisition of M or S are known (or not) and attractive is a task for Economics. When the benefits are known to exceed the costs (EVA>0), the knowledge acquisition solution will be trivially determined by the markets. The other situations – (i) costs that are known to exceed benefits and (ii) unknown costs and benefits – are subject to analysis by the public policy maker.

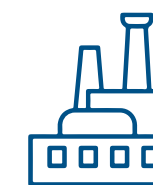
In these cases, the public policy maker should prioritize the allocation of its scarce resources in the search for

solutions for those situations in which prices, costs, and acquisition risks are unknown. Such resources would be allocated exactly to address economic restrictions resulting from information scarcity. This process of revealing market information produces informational externalities (Rodrik, 2004), that is, all other market participants now have access to information related to fundamental parameters (prices, costs, risks, and minimum viable scale) to assess the viability new projects, as well as to price (Valuation) existing assets.

In these cases, public policy intervention may require coordination and mobilization of public and private resources, in the form of venture capital which, in this case, would exercise the function of generating data and market information. There is no need for the mobilization of public resources to have a perennial nature. The intervention is punctual, that is, limited to activities hitherto unexplored due to lack of information. Equally limited are activities in which informational externalities have the potential to produce spillovers and replicable and scalable business models. It should also be limited in time, that is, enough time to produce the relevant marketing information about the new business model.

Some development banks have already played a major role in these situations. In reality, the production of clean and renewable energy, which currently constitutes a widely viable and competitive business model in LAC, in the past (not too distant) was unfeasible for several reasons, including uncertainties in relation to productivity levels (lack of knowledge of the real levels of insolation and intensity of winds and their intermittence) and the high production costs resulting from reduced scales of production. When key market information was revealed, business models scaled and CAPEX and OPEX rapidly declined, as already mentioned.

In those cases where the costs are known to exceed the benefits, the acquisition will only be made possible through a subsidy. However, if the intervention – in this case, the subsidy – demands continuity (perpetuity), the uncertainty about its maintenance (subsidy withdrawal risk) tends to grow over time. Such a situation of growing uncertainty can turn



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into underinvestment by policy beneficiaries (Nagy, Hagspiel, and Kort)⁹⁷, which would add another obstacle to the economic sustainability of the activity.

Another important role to be played by public policy is to ensure coordination externalities (Rodrik, 2004). To elucidate this point, let us take a “textbook example”. Imagine a situation in which the economic viability of economic activity X is conditioned to the economic viability of activity Y, and vice versa. Additionally, let’s imagine that both parties are linked in a relationship between buyer and seller, in a production chain. Finally, consider that both activities require high levels of investment (CAPEX) in specific and non-recoverable assets.

Such a situation reflects a classic Hold-Up problem (Williamson, 1979)⁹⁸. If there is a bargain between

⁹⁵ Hausmann, Ricardo e Rodrik, Dani (2003). “Economic Development as Self-Discovery”. Journal of Development Economics, vol. 72, December 2003.

⁹⁶ Hidalgo e Hausmann (2009). “The building blocks of economic complexity”. PNAS, Proceedings of the National Academy of Sciences Vol. 106 (26).

⁹⁷ World Economic Forum (2019). “These are the most complex economies around the globe”. Web Forum. See: <https://www.weforum.org/agenda/2019/12/countries-ranked-by-their-economic-complexity>. 2015. See: <https://www.europarl.europa.eu/news/en/headlines/economy/20151201ST005603/circular-economy-definition-importance-and-benefits>

⁹⁷ Nagy, Hagspiel e Kort (2021). “Green capacity investment under subsidy withdrawal risk”. Energy Economics, Volume 98.

⁹⁸ Williamson, O.E. (1979). “Transactions-Cost Economics: The Governance of Contractual Relations”. Journal of Law and Economics, 22(2), pp. 233–62.

X and Y on the economic profits generated along the production chain, neither party would have an incentive to be the first to invest, as this would put it at a disadvantage in the bargaining process. Therefore, in the absence of coordination, investments will definitely not take place. Coordination by a third party (in the form of public policy) would enable the creation of a production chain that would otherwise not exist. Here, there is no reason to mobilize resources other than those strictly necessary for the exercise of coordination.

Problems of an informational and coordination nature can restrict the potential gains arising from the comparative advantages in the production of renewable energy enjoyed by LAC. In this sense, a set of public interventions - in the form of an industrial policy - is really necessary. However, the understanding of authors such as Dani Rodrik seems adequate, for whom an industrial policy must be oriented towards processes, and not results, as is the case of the examples (producing relevant information and coordinating investments) mentioned above.

Additionally, the “ten principles for formulating industrial policy”, suggested by Rodrik (2004), seem adequate and are a reference in this sense. They are:

1. Incentives should only be directed towards new activities.
2. A benchmarking criterion for evaluating the success or failure of the intervention must be clearly established, *Ex ante*.
3. The need for well-established sunset clauses, so that the human and financial resources allocated

in public policy are not linked for a long period to projects that are known to be unfeasible.

4. public support should be directed towards activities rather than sectors. This includes, for example, bilingual training, investments in infrastructure, the adaptation of foreign technologies to domestic conditions, venture capital, etc.
5. The benefited activities must have clear potential for spillover effects and demonstration effects.
6. Every country has some pockets of competence and bureaucratic technical excellence. These agencies - which enjoy an excellent reputation - must be responsible for formulating and conducting industrial policy.
7. The work of agencies should be periodically monitored and evaluated.
8. Agencies must maintain permanent communication channels with the private sector, while the risk of capture must be mitigated
9. Errors and failures are inevitable and constitute the nature of these processes. Therefore, the objective of the policy is not the minimization of failures (even because the disclosure of unfeasible activities also constitutes an informational externality), but the minimization of their costs; and
10. The benefited activities must be able to renew themselves, so that the cycle of discovery is continuous, and the intervention is temporary.



In these cases, public policy intervention may require coordination and mobilization of public and private resources, in the form of venture capital which, in this case, would exercise the function of generating data and market information.



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WHICH PUBLIC POLICIES?

Below there is a list of points that could be included in a public policy agenda to foster and encourage Powershoring in LAC. The list is not exhaustive and aims, above all, to offer an initial menu of measures. The proposed measures are generic and are not specifically targeted at any of the countries studied in this report. The policies are pertinent to federal, state, and municipal governments and regulatory agencies, depending on each country. The most important thing is that the three levels of government and the agencies work together and seek synergies and complementarities. Each of the measures listed requires due detailing in order to adapt to the different realities. Public policies must be articulated and complemented by private ones, with the active participation of business associations and guilds, and other entities representing the private sector.

Ultimately, Powershoring can be classified as an industrial policy, as it promotes the transformation of the productive structure. However, unlike other industrial policies previously implemented in the region, it is a policy that has clean energy, foreign direct investment, exports, technology, and innovation as its central points, and its progress is not necessarily dependent on tax incentives, subsidies, protectionism, or discrimination. On the contrary, the fulcrum of the strategy is in the comparative advantages, the natural resources, and climate change. It is, therefore, an innovative proposal for industrial policy, in which climate change and the strengthening of markets are its starting points.

The list of proposed measures must be seen in full, in order to boost the Powershoring agenda from different business perspectives. It should be highlighted that the greatest policy challenge is that of coordination and articulation among the entities involved, as well as between the public and private sectors.

We have listed initial measurements for consideration.⁹⁹

- One-stop shop for foreign companies interested in Powershoring.
- A regulatory and contractual structure that enables the financing of green and renewable energy projects and H2V projects

- Policies for compliance with the ESG agenda for investments within the scope of Powershoring.
- Promoting the availability of green energy in EPZs
- Adjustment of port infrastructure for the movement of cargo of manufactured products and industrial inputs.
- Promotion of the EPZs policy.
- Institutional strengthening of EPZs to accommodate more and new industrial plants.
- Development of retro industrial areas and other support infrastructure in ports.
- Infrastructure for the full functioning of EPZs, including roads, water, sanitation, energy, access, and security.
- Urban development close to EPZs, including schools, housing, health centers, and leisure.
- Fast and practical customs services in port areas and EPZs.
- Appropriate norms for PPA (power purchase agreement), including in dollars, dedicated to EPZ.
- Construction and management of transmission lines and gas pipelines, when necessary.
- Special rules for importing equipment for Powershoring industrial plants.
- Promotion of new investment agreements and trade agreements.
- Promotion of double taxation agreements with countries most interested in Powershoring.
- The attraction of H2V production projects.
- The attraction of investments in the production of wind, solar, and hydrogen energy equipment.

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⁹⁹ The list below is not arranged in order of priority.

- Promotion of specialized industrial support services, general services for industrial zones, and specialized professional services.
- Involvement of universities and research and innovation centers in the Powershoring strategy and support to industrial plants in R&D, quality, and processes.
- Creation of research and innovation centers in green energy and H2V.
- Public labor recruitment services.
- Training services and professional training.
- Promotion of bilingualism in English.
- Attracting new shipping lines to ports involved in Powershoring.
- Pre-identification of countries, sectors, and companies potentially beneficiaries of Powershoring.
- Roadshow by export promotion agencies and investment attraction to “sell” Powershoring.
- International and institutional marketing of Powershoring at fairs, specialized events, guilds, specialized magazines, and other areas.
- Approaching foreign companies that are already in LAC to become allies and/or participants in Powershoring.
- Evaluate measures to protect commercial interests with bodies such as the WTO.
- Work with investment funds and investors potentially interested in Powershoring and who can be allies of the agenda.
- Promotion of internal articulation and coordination between government agencies.
- Promotion of regulated and voluntary carbon markets to serve the interests of companies involved in Powershoring.
- Approaching international institutions potentially interested in Powershoring, such as UNCTAD.
- To seek support from international climate funds and financing agencies to support Powershoring.
- Identification of national and international private companies potentially interested in businesses that benefit from Powershoring, such as law firms, consulting firms, investment funds, producers of wind, solar, and hydrogen energy equipment, logistics companies, financial services, and providers of services and inputs, among others.
- Provision of de-risking financial instruments to attract investment, especially in projects with the highest impact on production chains and value addition.
- Ensuring regulatory stability.
- Approval of tax laws that encourage industrial production for export.
- Stimulation of fast-track mechanisms for environmental licensing and authorizations.
- Incorporation of Powershoring in long-term energy planning.
- Training and equipping investment promotion agencies.
- Availability of information to investors, especially those from sectors and countries with greater potential interest.
- Promotion of standardization and processes for Powershoring.
- Coordination and mobilization of public and private resources in the form of venture capital and blended finance.
- Generation of data and marketing information.
- Public interventions of industrial policy based on incentives and oriented to processes and not to results.
- Compliance with the principles for formulating industrial policy suggested by Rodrik (2004).

It is necessary to point out that several LAC countries already have, to different extents, know-how about many of the institutions and public policies mentioned above. Additionally, some innovative initiatives have been created. A recent example worth mentioning is the initiative of the Chilean state development agency, Corporación de Fomento de la Producción (Corfo), which launched a request for information aimed at companies interested in manufacturing or assembling electrolyzers and associated components in the country to the production of H2V¹⁰⁰. Such an initiative is adherent to the Powershoring agenda, since “the call is part of a national initiative to accelerate the development of a green hydrogen and derivatives sector, as well as use this as a lever to stimulate industrial and regional development” (Bnamericas, 2023a)¹⁰¹.

However, there is still much work to be done. As highlighted by the International Renewable Energy Agency, “having access to abundant renewable sources is an asset” for LAC, but it is not everything. This is a necessary, but not sufficient, condition for playing a leading role in the energy transition and building a global green industry. “Many other factors come into play”, including infrastructure, the current configuration of energy matrices, the cost of capital, and access to the necessary technologies (Bnamericas, 2023b)¹⁰².



Photo: Adobe Stock



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¹⁰⁰ See: <https://www.corfo.cl/sites/cpp/rfi-electrolizadores-h2v>

¹⁰¹ Bnamericas (2023a). “Em meio a iniciativa por hidrogênio verde, Chile emite chamada para eletrolisadores”. Bnamericas. See: <https://www.bnamericas.com/pt/noticias/em-meio-a-iniciativa-por-hidrogenio-verde-chile-emite-chamada-de-eletrolizador>

¹⁰² Bnamericas (2023b). “Estímulo à produção de eletrolisadores no Chile pode trazer benefícios”. Bnamericas. See: <https://www.bnamericas.com/pt/noticias/estimulo-a-producao-de-eletrolisadores-no-chile-pode-trazer-beneficios>

HOW CAN MULTILATERAL DEVELOPMENT BANKS CONTRIBUTE?

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We believe that the Multilateral Development Banks (MDBs) can play an important role in supporting the development of the Powershoring strategy in LAC. Most MDBs operate throughout the region, with an emphasis on infrastructure projects. The region also has a wide network of national and regional economic and social development banks, in addition to local development agencies that maintain a historical relationship of partnership and technical cooperation with the MDBs. How MDBs contribute to Powershoring are varied and we point out here five possible vectors of support and participation.

The first one concerns the promotion and dissemination of knowledge through the production and publication of studies and research, including technical reports, and economic and financial feasibility studies, with emphasis on the feasibility of production plants for the green energy production chain, in addition to technical inputs for the regulatory and institutional design and improvement of the Powershoring agenda.

The second vector concerns the organization of technical events on Powershoring. We understand that the success of the Powershoring strategy will require a wide range of public (institutional) and private innovations (products, processes, market, organizational, and supply chains), the dissemination of knowledge and know-how acquired throughout this process, as well as a lot of retraining of the workforce. Not all technical or technological knowledge can be disseminated through manuals, reports, technical notes, and articles since a relevant part of this type of knowledge is tacit in nature and is disseminated through personal contacts, communities of practice, and formal networks of knowledge. MDBs can play a leading role in the formation of such communities and cooperation networks.

The third vector includes a support structure for the list of public policies aimed at the development of Powershoring. As previously highlighted, the Powershoring agenda demands a public policy framework. MDBs can contribute technical assistance to the formulation and implementation of some of these policies, including support for Ex ante and Ex post evaluations, thereby providing a body of evidence on lessons learned, best practices and benchmarking, and other critical issues such as certification and contracting agendas.



The region also has a wide network of national and regional economic and social development banks, in addition to local development agencies that maintain a historical relationship of partnership and technical cooperation with the MDBs

The fourth vector includes support in articulating stakeholders on the agenda. Here, MDBs can serve as a platform, providing greater efficiency in building different forms of cooperation between the parties by providing greater transparency to processes, reducing transaction costs and risks associated with information asymmetry, in addition to providing reputational capital for the Powershoring agenda. It should also be considered that Powershoring can be a powerful platform for regional integration, a topic of great interest to regional BMDs.

Finally, the fifth vector is associated with credit, by means of supporting the structuring of (i) operations to attract resources, such as issuances of thematic bonuses (green bonds), (ii) risk management (guarantees, collaterals, instruments of hedge and various insurance); and (iii) other financing instruments for green energy plants and necessary infrastructures for projects under Powershoring.

FINAL CONSIDERATIONS

There is no way for developed regions and China to significantly reduce their CO₂ emissions without curbing the growth rate of their economies, which could lead to an even slower and more politically costly energy transition. The need to prioritize the use of energy, commitments to the Paris Agreement, exposure of industrial production to geopolitical issues and rising costs seem to make unequivocal the attractiveness of LAC as a partner for energy security and to accelerate decarbonization, guarantee the security of industrial supply and reduce the pressure of energy costs.

Are the factors that encourage Powershoring transitory or permanent? The situation of insecurity and fossil energy prices will still remain complicated for a long time, whether for geopolitical, regulatory reasons, or lack of investment in specific infrastructures. Dependence on imported fossil energy should decrease over time with the entry into service of renewable energy stations, but the greening of the energy matrices of the large importing economies will still take a long time. Carbon regulations and taxes are expected to advance in the US and Europe, raising domestic costs and affecting business competitiveness. Geopolitical issues will probably remain on the agenda for a long time and energy insecurity associated with extreme weather and climate phenomena will also continue “taking their toll”.¹⁰³

Therefore, it seems reasonable to state that those incentives for Powershoring are rooted in permanent

or almost permanent and not transitory factors and that Powershoring would be a mitigation strategy for those “market failures”. After all, Powershoring reduces costs, increases efficiency and production security, improves resource allocation, protects competitiveness, accelerates decarbonization in the country of origin, and contributes to companies' compliance with the environmental agenda.

The LAC is especially well-positioned to be the destination for companies in need of Powershoring. Among the immediate enabling factors are the already green or very green energy matrix, the increase in the supply of renewable energy projects with decreasing marginal costs, the implementation of H2V production projects, the low exposure to geopolitical tensions, the increasing tightening of regulations environmental compliance and ESG and investments in ports and industrial zones.

Powershoring is a unique opportunity to convert the region's comparative advantage in green energy and distance from the international geopolitical agenda into potent instruments to promote economic and social development. Powershoring will have important effects on productivity, competitiveness, technology and innovation, poverty, and income distribution, and will contribute to the formation and consolidation of regional value chains. Powershoring will certainly be very useful and beneficial for the region, but it will be even more useful for companies that understand the virtues of this strategy.



Powershoring is a unique opportunity to convert the region's comparative advantage in green energy and distance from the international geopolitical agenda into potent instruments to promote economic and social development.

¹⁰³ For a detailed discussion on how energy insecurity has become one of the most relevant topics of our time, see J. Bordoff and M.L. O'Sullivan, “The Age of Energy Insecurity”, Foreign Affairs, April 2023.



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