Growth Lab

Green Growth Opportunities for Hermosillo: "Powershoring"

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Executive Summary

The process of global decarbonization offers significant growth opportunities for Hermosillo, given its outstanding solar power potential. As fossil fuels are relatively cheap to transport, they created an "energy flat world," allowing industries to thrive in locations that are far away from energy sources. Renewable energy, however, is much more costly to transport. Because of this, energy-intensive industries are naturally incentivized to relocate to areas with competitive green energy in a decarbonizing world — something known as "powershoring" (Arbache 2022, Arbache & Esteves 2023). Powershoring is a green growth opportunity for Hermosillo; that is, a pathway for Hermosillo to accelerate its own economic growth through helping the global economy to decarbonize. Powershoring is becoming an increasingly important opportunity as businesses face carbon taxes and other costs in consuming fossil fuel energy, which come from both regulators and consumers (ibid.).

Hermosillo's powershoring strategy should involve both attracting new industries and exploring new growth opportunities for existing industries. On the intensive margin of existing industries, companies may expand by integrating renewable energy into their own consumption of renewable sources. Hermosillo can build on its strengths in the food and agricultural sectors. On the extensive margin of new industries, attractive opportunities arise in the chemicals manufacturing cluster, the glass and ceramics cluster, and the semiconductors and electronics cluster. The industries identified in these clusters can be targeted for potential investment promotion efforts, given their large energy demands. In this report, we provide initial observations on several of these industries from an investment promotion perspective.

To establish Hermosillo as a prime destination for industries seeking lower emissions, government and industry must work together on long- and short-term strategies. A significant obstacle is the intermittency of solar energy, which is subject to weather variability and the unavoidable reality that the sun does not shine at night. A current approach by companies is to use energy from the grid in combination with green energy certificates to offset resulting carbon emissions, but this practice is untenable for some end consumers. Over the longer-term, intermittency could be resolved through advances in battery storage and connections to neighboring regions, where wind power and other complementary renewable energy can be sourced. Since decarbonizing the grid is a long-term scenario, early movers can capitalize on opportunities through green industrial parks that provide a dedicated supply of renewable energy. The region's energy infrastructure will need to evolve to ensure stability, but the short-term focus should be on industries that align with Hermosillo's existing capabilities and renewable potential. Prioritizing sectors where processes are more easily electrified, and water needs are manageable appears to be the most logical place to begin a dynamic process of attracting and growing powershoring opportunities in Hermosillo.

1. Introduction

The global economy is undergoing a rapid transition toward a decarbonized future. With the Paris Agreement, 196 countries committed to ambitious climate targets through nationally determined contributions (NDCs), which outline each country's roadmap for reducing emissions. Achieving these targets requires significant transformations across sectors. The transportation sector must shift from internal combustion engines to electric vehicles (EVs). Manufacturing processes need to be electrified to minimize emissions from fuel consumption. Most critically, the electric grid must transition to renewable energy sources to support the entire decarbonization effort. These changes necessitate that countries, cities, and companies rigorously analyze how to reduce their carbon footprints, driving unprecedented demand for decarbonization solutions.

Meeting global decarbonization goals requires not only demand but also the ability to supply the necessary solutions. In a net-zero pathway, EV sales must increase by 18 times between 2020 and 2030 (IEA 2021), while global solar energy generation capacity must more than quadruple by 2030, spurring massive demand for solar panels (ibid). The shift to greener manufacturing will profoundly reshape global production patterns, as cheap and abundant renewable energy becomes a critical factor in industrial competitiveness. This global transformation presents enormous opportunities for regions that can supply the energy, tools, and technologies to decarbonize. Hermosillo, with its strategic potential, is well-positioned to seize this opportunity by aligning its growth strategy with the global demand for sustainable solutions.

Hermosillo's ability to help the world decarbonize offers a powerful growth strategy. The decarbonization wave is reshaping global production, creating new industries, markets, and opportunities. Economic policymakers in Hermosillo must evaluate how the city can position itself as a key player in offering solutions to these global challenges. This report focuses on the most promising strategies Hermosillo can adopt in this context, particularly the concept of "powershoring".

Historically, fossil fuels created what could be described as an "energy flat world", where low transportation costs of energy allowed industries to thrive far from their energy sources. The energy density and ease of transport of fossil fuels enabled countries with limited domestic energy resources, such as Germany and South Korea, to excel in energy-intensive activities like steelmaking. This dynamic allowed industrial powers to develop regardless of geographic proximity to energy sources.

Global decarbonization and the need to use renewable energy are signaling the end of this "energy-flat world." Renewable energy, while abundant and increasingly cost-competitive, is fundamentally different from fossil fuels in its transportability. Renewable electricity — such as that from solar and wind — is more expensive to

transport and requires significant infrastructure investment in power lines, which come with capacity limitations and transmission losses. Converting renewable electricity into transportable fuels like green hydrogen results in further energy losses and logistical challenges. As a result, renewable energy must be consumed closer to its source, creating a new reality in which proximity to green energy becomes crucial for energy-intensive industries. Fully decarbonizing energy-intensive industries will likely demand relocating them to regions with abundant, low-cost renewable energy. This shift marks the end of the era where fossil fuels allowed industries to flourish regardless of geography. Instead, the next phase of industrial growth will depend on proximity to renewable energy sources.

Regions that develop competitive renewable energy capacity have the opportunity to emerge as the new industrial hubs, but this entails overcoming several known challenges. Hermosillo, with its solar potential and growing focus on sustainability, is well-positioned to capitalize on this shift. Powershoring — the act of relocating energy-intensive industries to regions with plentiful green energy (Arbache 2022, Arbache & Esteves 2023) — offers a strategic opportunity for Hermosillo to contribute to global decarbonization while establishing itself as a leader in this new energy landscape. While the opportunities presented by powershoring and renewable energy are vast, significant challenges remain. One of the primary obstacles is the intermittency of renewable energy sources like solar and wind. Unlike fossil fuels, which provide consistent and easily stored energy, renewables are dependent on weather conditions and time of day, making it difficult to ensure a constant energy supply for industries that require continuous, high-capacity power. Additionally, electrifying certain industrial processes poses a technical challenge. Many industries, such as steel and cement manufacturing, require extremely high temperatures that are traditionally achieved through the combustion of fossil fuels. Electrifying these processes with renewable energy is not only complex but also expensive with current technologies. However, overcoming these hurdles offers immense potential. Developing solutions to these challenges — whether through advancements in energy storage, industrial electrification, or new technologies — could unlock substantial gains for regions like Hermosillo. As the world races to decarbonize, the global demand for solutions to these issues will be enormous, positioning those who can address them at the forefront of the green economy.

2. Powershoring – A New Comparative Advantage for Hermosillo?

The decarbonization of production processes around the world will lead to a significant reshaping of comparative advantages in industrial production from which Hermosillo stands to gain. The end of the energy-flat world starts a dynamic from which places with abundant renewable energy resources will benefit. Countries with a large presence of energy-intensive industries but low renewable potential will face challenges in retaining these industries in a decarbonizing world. This chapter will assess Hermosillo's potential within this context and highlights the potential challenges that it will face.

Rationale & Challenges of Powershoring in Hermosillo

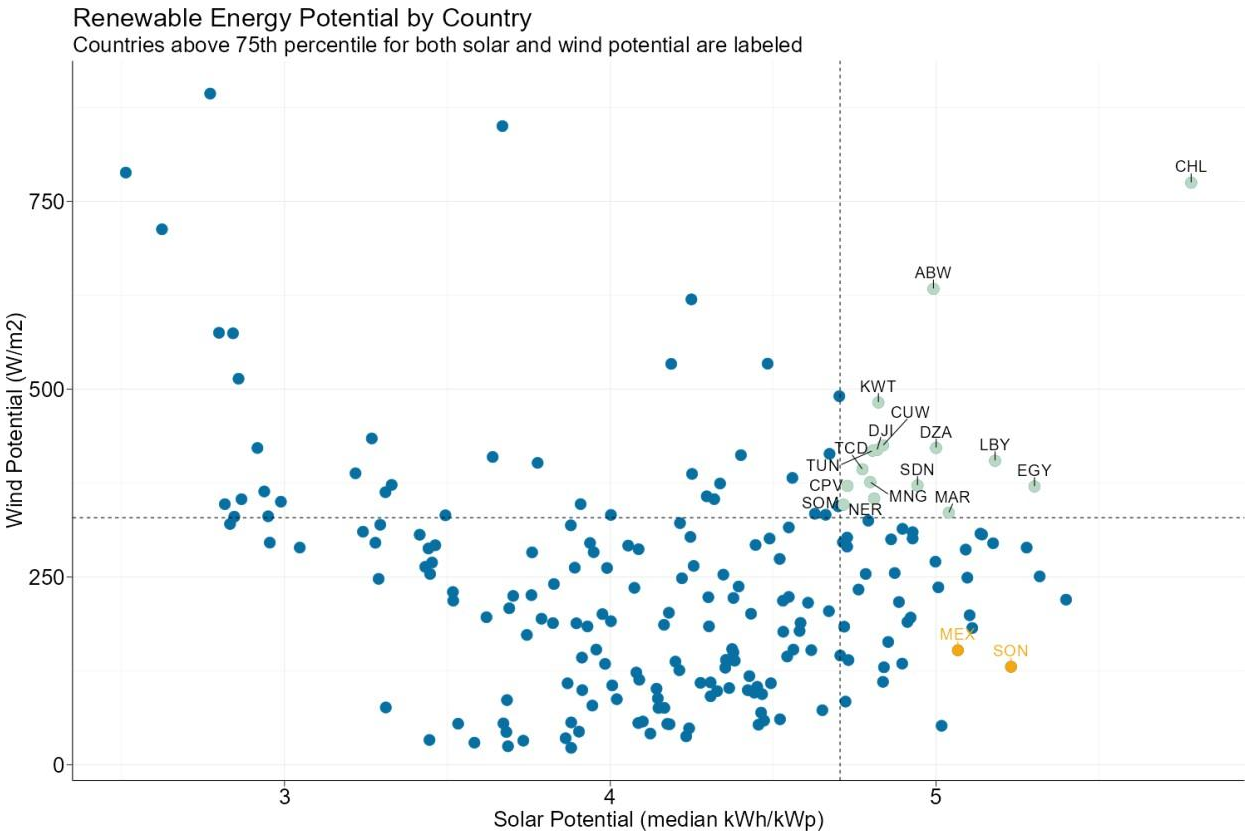
The switch from a fossil fuel-based production to one powered by renewable energy sources will have its largest impact on energy-intensive industries. Industries for which energy costs are a large share of their overall costs will be sensitive to changes in the respective prices. Not only are they sensitive to price changes, but due to the introduction of carbon prices in jurisdictions such as the EU, they also face pressure to decarbonize their production processes. Their energy-intensiveness makes them high emitters of greenhouse gases. In this context, many companies will try to electrify their production processes with renewable electricity at competitive prices. Due to large geographical differences in the price and availability of renewable electricity, they may consider relocating their production to locations that offer more competitive renewable electricity prices. This relocation effect is also called the "renewable pull" (Verpoort et al. 2024).

Mexico has very competitive renewable energy potential at a global scale. The country's solar power potential is among the best globally. Figure 1 shows the renewable energy potential across countries. The x-axis indicates the solar power potential, and Mexico lands in the 93rd percentile of all countries. Within Mexico, Sonora is one of the states with the highest solar power potential. If Sonora were a country, it would be in the 97th percentile of the global distribution of solar power potential. However, both Mexico's and Sonora's wind resources are less abundant, as. they rank in the 31st and 25th percentile, respectively. Leveraging solar and wind resources together is helpful, when possible, to counterbalance potential issues of intermittency.

Hermosillo will have to face the challenge of intermittency if it wants to provide continuous renewable energy to those who demand it. Given the low wind power potential of Sonora, the intermittency of solar resources will be an issue for Hermosillo in the context of powershoring. The continuous supply of renewable energy solutions would have to involve storage options, such as battery storage, or other renewable energy sources such as hydropower. Additional support could come through interconnections

with wind generation sites in neighboring Chihuahua or Baja California.[1] This is an issue many places will face, as few countries have good solar and wind resources with complementary generation profiles. Figure 1 highlights the few countries that do have large potential in both areas. This includes countries such as Chile, which may indeed become attractive investment locations, but many other countries in this category are either unattractive due to current instability (Libya, Chad, Sudan, Djibouti) or are relatively small in land area, which limits their generation potential (Aruba, Curaçao, Cabo Verde).

Figure 1: Renewable Energy Potential



Note: The variable on the x-axis is an indication of the practical solar potential of a place. The unit kWh/kWp indicates the kWh of electricity that would be generated by a PV system with a 1kW peak installed capacity. The variable on the y-axis indicates the wind power potential. The unit W/m2 indicates the mean wind power density at a height of 100m. Sources: ESMAP 2019; Davis et al. 2023

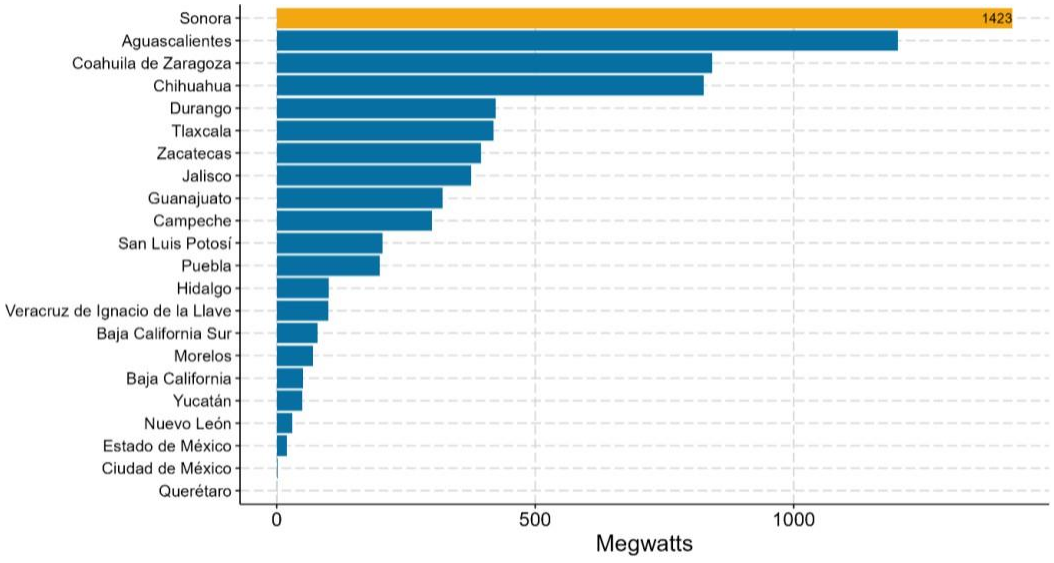
Another viable strategy for actors in Hermosillo is to provide renewable energy during hours of sunlight and buy renewable energy certificates for those hours during which the generation source will likely be gas. This is a strategy that is currently being adopted, but it is also contested regarding its true impact (Bryan,

[1] While Baja California and Baja California Sur currently only have an installed wind capacity of 90MW and Chihuahua has no installed capacity, both of these states have some areas with higher potential (see Appendix).

Hodgson, and Tauschinski 2024). Ultimately, this will be driven by the demands from potential investors, who in turn are subject to the demands of their markets. It may be sufficiently attractive for some companies to source most of their power directly from solar power and claim that in the downtime of solar, their generation is covered by renewable energy certificates. However, even for this strategy, Hermosillo would have to be able to offer significant solar capacity to be competitive.

Sonora is at the forefront of Mexico's renewable energy potential and development. For a long time, the electricity system of Mexico has relied on fossil fuels. However, since 2014, the country has started to develop its renewable energy capacity. The country's outstanding solar power potential is concentrated in its North. Together with Chihuahua and Coahuila, Sonora has the largest solar power potential in the country. Additionally, Sonora benefits from having a significant amount of available land.[2] This is why a large share of the buildout in solar generation is occurring in Sonora**.** Sonora has received the most investments in renewable generation assets among Mexcian states, with a total of 12 solar PV parks developed as of 2023 (Figure 2). With the "Plan Sonora," the Lopez Obrador administration decided to double down on this. It designates Sonora as the state to lead the country's renewable energy buildout. The "Plan Sonora" includes the development of 1GW of new solar power generation capacity in the Puerto Peñasco power plant.

Figure 2: Solar Generation Capacity across Mexican States (2023)

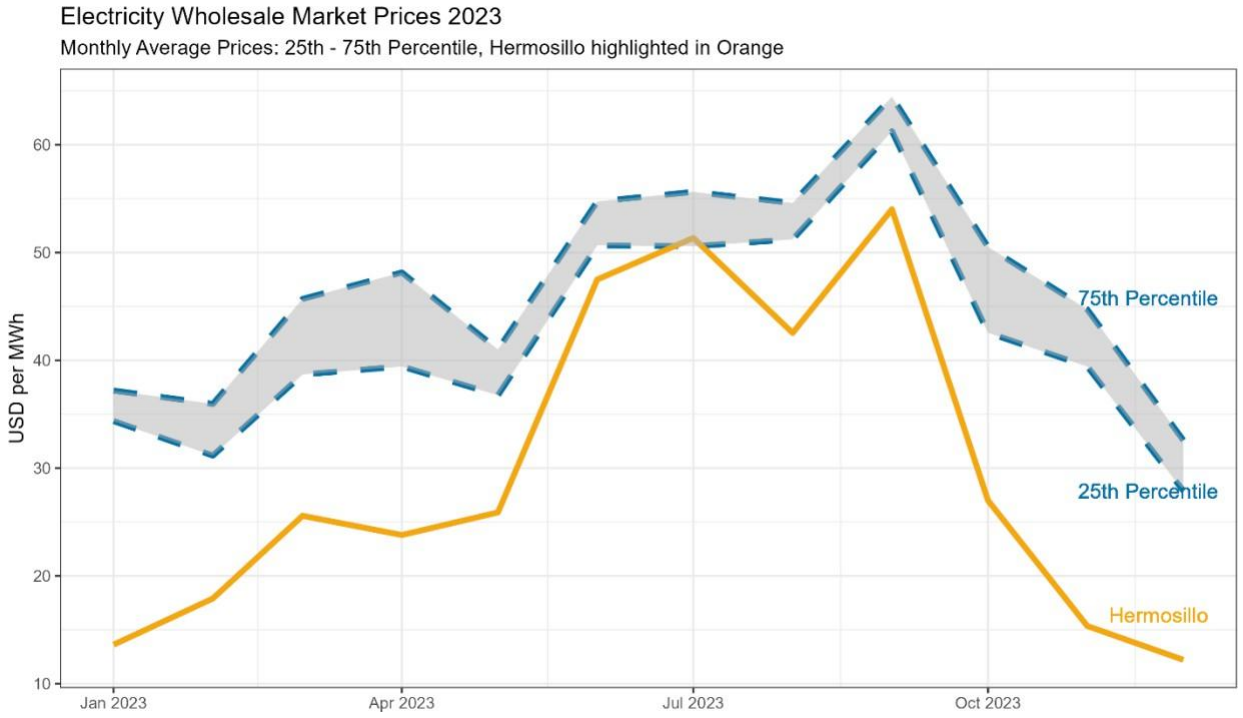


Source: SENER 2024

[2] Sonora ranks third in all Mexican states in terms of bare land. Coahuila and Chihuahua rank first and second with 65.5bn and 65bn sqm of bare land. Sonora comes in third with 35.2bn sqm of bare land.

This growth in solar power development, as well as the capacity from existing natural gas power plants, created a significant power generation capacity surplus in Sonora. Currently, Sonora's current installed electricity capacity is 9.47GW while its maximum demand is 5.6GW. This makes Sonora a net exporter of electricity. It also means that in many cases, the wholesale electricity price in Hermosillo is among the cheapest in the country (Figure 3). Due to the structure of the electricity market, this price advantage is something that only large industrial customers ("usuarios calificados") can access. Access to the wholesale market is only granted to customers with a minimum demand of 1MW. Another option is to pool demand together to reach this threshold and then access the wholesale electricity market. This is a strategy that is viable for industrial parks and that actors in other regions, such as Querétaro, are already adopting (Estrella 2024).

Figure 3: Electricity Wholesale Market Prices 2023



Source: CENACE 2024

Sonora's excess electricity supply is notable, since many investors find access to electricity to be a constraint in the country (Escalera et al. 2024). The constraint faced by investors is due to increased demand stemming from nearshoring investments taking place in the North of the country as well as insufficient transmission buildout. Locations are struggling to supply electricity to new businesses locations at the time and cost that these businesses need. Given the already constrained electricity environment, some of

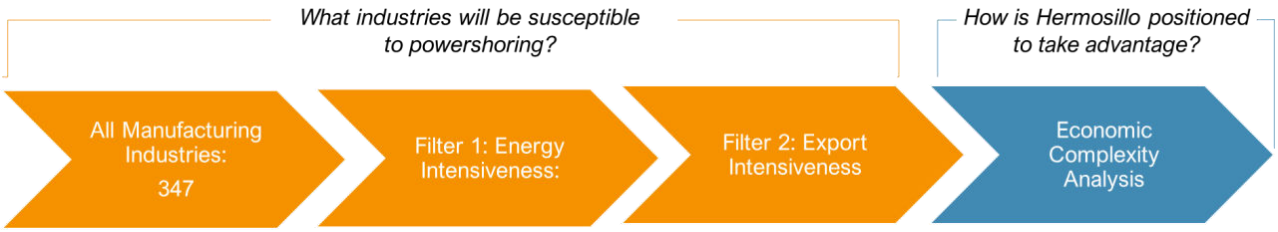
these other regions that are facing this problem may find it more difficult to attract energy-intensive investments, at least in the short-term.

For powershoring to be viable in Hermosillo, potential investors will require dedicated renewable energy supply — this makes green industrial parks a big opportunity. Although the buildout of renewable energy generation in Sonora has significantly picked up pace, as of 2022 only 25% of the overall generation capacity in Sonora comes from renewables (Secretaría de Energía 2024). Continued rapid expansion may be possible, but universal power supply from renewables is a long way away. Offering a dedicated supply of cheap renewable energy in an industrial park would be a way to attract powershoring industries. For brevity, we call these industrial parks with dedicated supply of renewable energy "green industrial parks". These green industrial parks could also adjust to the needs of potential investors with storage solutions. They offer the opportunity to use the renewable energy potential of Sonora for its economic development without needing to wait until its overall grid has been sufficiently "greened".

3. Identifying Potential Industries for Powershoring

Hermosillo's new comparative advantage should be recognized by its policymakers. It should inform future investment promotion activities and the continuous development of the energy system. To that end, policymakers need to understand which industries are potentially susceptible to the powershoring dynamics explained above. This chapter will focus on identifying those industries. This is helpful for potential investment attraction activities and the subsequent analysis of Hermosillo's current capabilities in these industries. Figure 4 indicates the logic of the following analyses and the analytical framework of this chapter (the orange segment) and the following chapter.

Figure 4: Analytical Framework



Source: Own elaboration

The key factor driving the impact that the "end of the energy flat world" has on industries is their energy intensiveness. It is possible to identify the most energy-intensive industries based on their electricity and fuel consumption expenditures. This can be done based on data from the US Economic Census 2018. We calculate the energy intensiveness as the sum of electricity and fuel expenditures of total revenue:

$$(1)\ Energy\ Intensiveness_i = \frac{Electricity\ Expenditures_i + Fuel\ Expenditures_i}{Total\ Revenues_i}$$

This follows the data and definition used to determine energy-intensive and trade-exposed industries in the American Clean Energy and Security (ACES) Act of 2009 and in the literature (Creason et al. 2021). We identify energy-intensive industries as those for which energy expenditures reach at least 2.5% of total revenues. In the ACES Act of 2009, the threshold was chosen to be 5% as the act's regulations were meant to establish exemptions from emissions targets. For this purpose, a lower cutoff might be warranted since more industries will be sensitive to price differential in renewable electricity. The cut-off chosen here is the 80th percentile.[3] It is somewhat arbitrary, and the higher the energy intensiveness, the more the renewable pull will come to bear.

An additional factor to consider is the trade intensiveness of a specific industry. The targeting should avoid industries that do not often trade their final products beyond the local economy. This could be because transport costs are too high, so the final product is sensitive to distance. An example of this is cement. The cement industry is highly energy intensive; its energy expenditures make up 15.8% of total revenues and it therefore easily clears the threshold established above. However, due to the high costs associated with transporting cement, it does not get exported very much. Hermosillo's strategy should be focused on attracting investments from industries that are both energy-intensive and frequently engage in trade. After all, the companies that this strategy is attempting to attract are companies that will not serve the local market but rather export their goods to either foreign or other domestic markets. Additionally, industries that cater to global markets are most likely to experience powershoring as green certificates and decarbonization efforts move forward in advanced economies such as the USA and the EU. Unfortunately, there is no data available on inter-regional trade within Mexico, so we focus on industries that tend to export to foreign markets. Formula (2) is used to calculate this measure of export intensiveness. To meet our criteria in this analysis, the industry must derive at least 10% of its total revenues from exports.[4]

$$(2)\ Export\ Intensiveness_i = \frac{Exports_i}{Total\ Revenues_i}$$

Applying these filters to the data from the US census reveals that 33 industries meet these criteria at the six-digit NAICS level — we will call these powershoring

[3] The distribution of energy intensiveness across industries at the 6-digit NAICS level is as follows: 1st Quartile: 0.6%, Median: 1%, 3rd Quartile: 1.85%

[4] This is deliberately chosen to be a low barrier. The intent is to filter out industries that do significantly engage in exporting their products. But since the USA is a very large market in itself some industries may also have most of its customers domestically. That is why we choose a cut-off of 10% here.

industries going forward.[5] Table 1 provides an overview of the 15 most energy-intensive industries from the list of identified powershoring industries. The full table of powershoring industries can be found in the appendix in Table A.2 . The 33 industries can be summarized by seven clusters: chemical manufacturing, textiles and fabrics, paper and wood products, glass and ceramics, metal and mineral processing, semiconductor and electronics as well as food and agricultural processing. These are the industries that will likely be susceptible to the dynamics of powershoring. Differential energy prices will be a significant pull effect for them as energy costs are a large component of their overall expenditures. These industries naturally group into roughly seven clusters as shown in Figure 5.

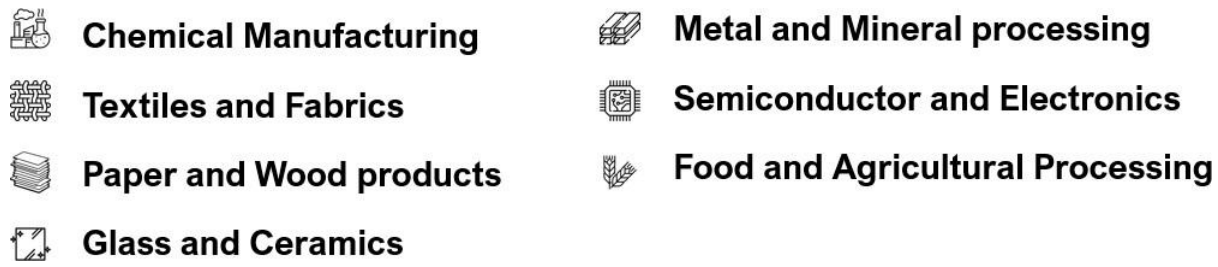
Table 1: Powershoring Industries – Top 15 Most Energy-Intensive Industries

NAICS Title	Cluster	Energy Intensity (%)	Export Intensity (%)	Avg. Revenue per Firm in the US (M USD)
Newsprint Mills	Paper and Wood Products Manufacturing	21.84	31.48	110.0
Alumina Refining and Primary Aluminum Production	Metal and Mineral Processing	18.09	46.33	132.9
Nitrogenous Fertilizer Manufacturing	Chemical Manufacturing	8.15	15.11	37.6
Ice Manufacturing	Food and Agricultural Processing	7.77	10.71	2.8
Other Basic Inorganic Chemical Manufacturing	Chemical Manufacturing	7.18	44.10	84.4
Flat Glass Manufacturing	Glass and Ceramic Products Manufacturing	6.21	20.35	54.5
Other Pressed and Blown Glass and Glassware Manufacturing	Glass and Ceramic Products Manufacturing	6.07	50.74	9.0
Mineral Wool Manufacturing	Glass and Ceramic Products Manufacturing	5.04	16.17	36.8
Clay Building Material and Refractories Manufacturing	Glass and Ceramic Products Manufacturing	4.70	13.75	15.2
Rendering and Meat Byproduct Processing	Food and Agricultural Processing	4.61	25.73	48.2
Iron and Steel Mills and Ferroalloy Manufacturing	Metal and Mineral Processing	4.55	15.99	518.1
Paperboard Mills	Paper and Wood Products Manufacturing	4.31	16.46	528.0
Pulp Mills	Paper and Wood Products Manufacturing	3.89	82.29	361.2
Plastics Material and Resin Manufacturing	Chemical Manufacturing	3.75	33.17	103.2
Semiconductor and Related Device Manufacturing	Semiconductor and Electronics Manufacturing	3.68	89.06	70.3

Source: Own elaboration based on US Economic Census 2018

[5] Any mining industries have been excluded from this list because the main activity itself relies on the presence of natural reserves to be mined. The processing of the minerals on the other hand is an economic activity that falls within the scope of what could be feasible within this strategy.

Figure 5: Powershoring Clusters



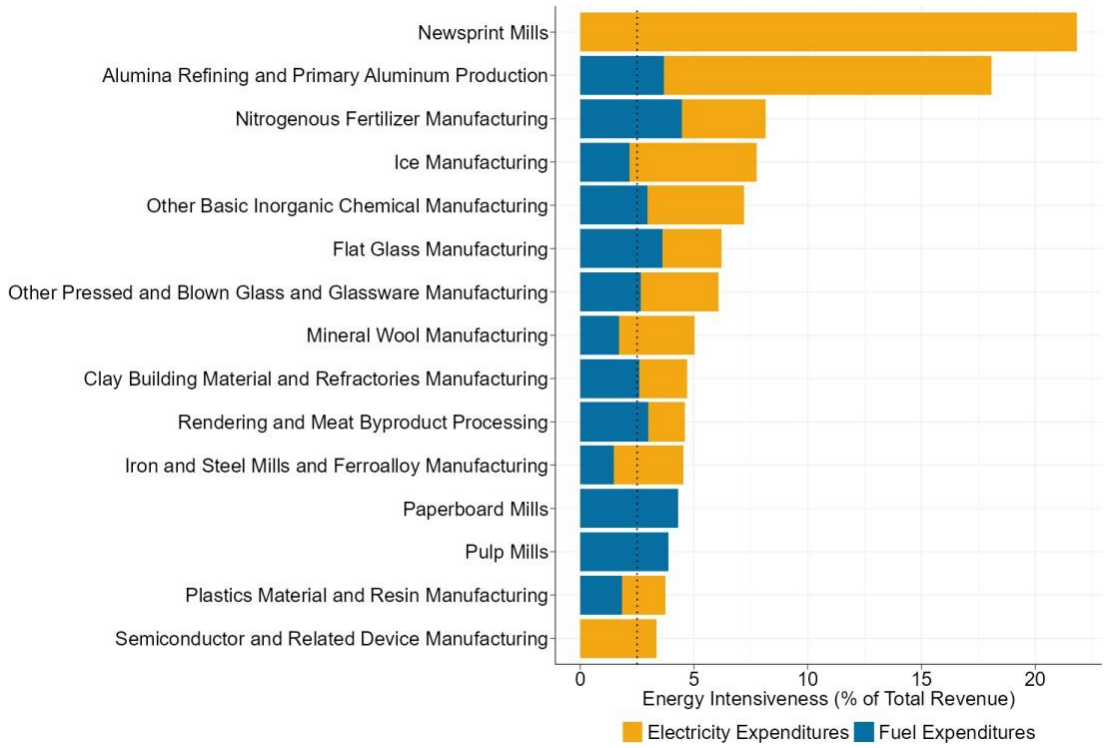
Source: Own elaboration

It is important to note that the use of energy in these industries often differs between electricity and fuel. For example, they visibly differ in the extent to which their energy use is driven by fuel versus electricity consumption.

Figure 6 shows to what extent either factor drives the energy intensiveness of the 15 most energy-intensive industries from this list. While the energy expenditures of aluminum refining are primarily driven by electricity, the expenditures of paperboard and pulp mills are entirely driven by fuel expenditures. This is relevant because industries will only be attractive targets for the strategies insofar as their production processes can be powered by electricity. Currently, dominating fuel expenditures can still indicate an attractive target if these processes can be electrified.[6]

[6] The paper industry (including paperboard and pulp mills) uses fuels for heating and drying purposes. These are processes for which electrification seems to be a promising way to reduce emissions (Furszyfer Del Rio et al. 2022).

Figure 6: Electricity vs. Fuel Demand Top 15 Energy Intensive Industries

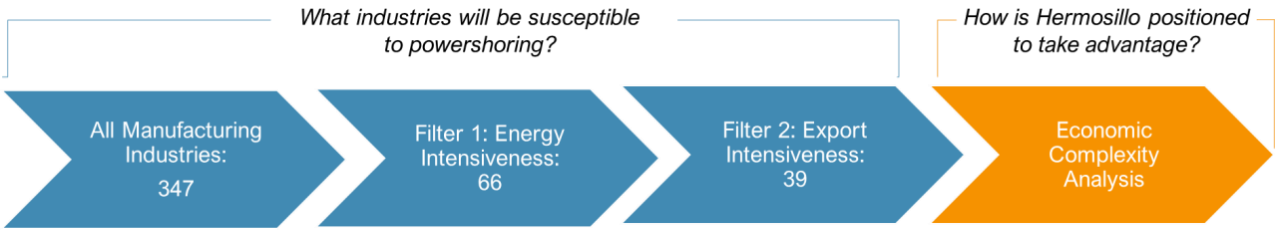


Source: Own elaboration based on US Economic Census 2018

4. Hermosillo's Current Positioning in Powershoring Industries

The identified powershoring industries present promising opportunities for investment in Hermosillo. Assessing how closely these opportunities align with the city's existing productive structure will be essential toward efforts to actively recruit companies in these industries. Powershoring is reshaping global comparative advantages, highlighting new countries and regions with abundant renewable energy potential as attractive destinations for investors. Beyond energy, factors like local expertise and the availability of skilled labor will also play a significant role in investment decisions. Therefore, an effective powershoring strategy should be grounded in the region's current productive capabilities. Factors such as the feasibility and attractiveness of these potential targets can inform how to best pursue them. This chapter will use economic complexity methods to evaluate Hermosillo's potential in powershoring industries.

Figure 7: Analytical Framework

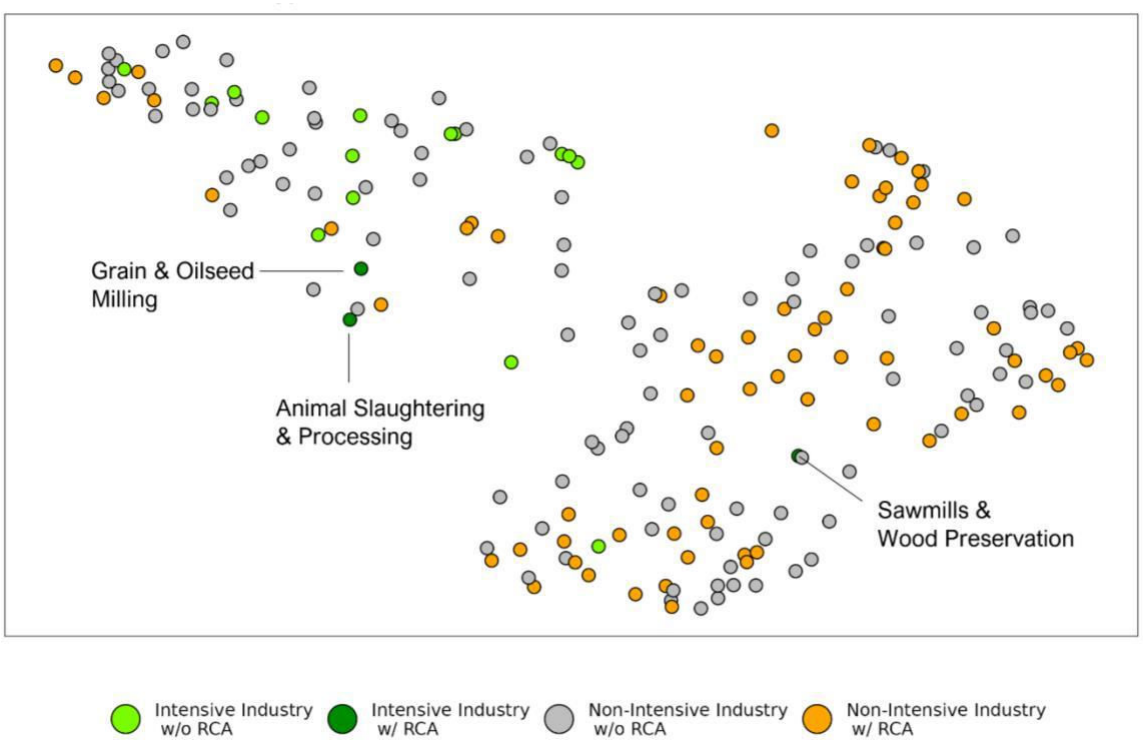


Source: Own elaboration

Many of the powerhsoring industries are not close to the existing productive structure of Hermosillo. In Figure 8, we put the powershoring industries in the context of Hermosillo's current position within the industry space. We can derive this using the economic complexity metrics that build on the work from Hausmann et al. (2014) and have been applied to the context of Hermosillo in earlier Growth Lab reports (Fortunato et al. 2024).[7] A detailed explanation of the variables can be found in Box 1 of the Appendix. Every dot visualizes an industry, and its proximity to another industry within the graph indicates their similarity. The powershoring industries are shown in dark green if Hermosillo has established a competitive presence and light green if that is not the case. The powershoring industries in which Hermosillo has already established a competitive presence (i.e., RCA >= 1) are *animal slaughtering & processing*, *grain & oilseed milling,* and *sawmills & wood preservation*. Although Hermosillo is already present in these industries, they may present opportunities for further growth — this is the "intensive margin". Existing or new companies in these industries could differentiate their products if they were mainly produced using renewable energy. The powershoring industries highlighted in light green are industries which Hermosillo could enter. They represent growth opportunities at the extensive margin.

[7] A caveat of this analysis is that the complexity metrics are calculated at the 4-digit SCIAN level while the initial identification of target industries is based on the 6-digit SCIAN level. We choose the respective 4-digit codes from the 6-digit industries shown in **Table 1**. While this introduces some noise to analysis, we believe that it is still informative.

Figure 8: Powershoring Industries and Hermosillo's Capabilities

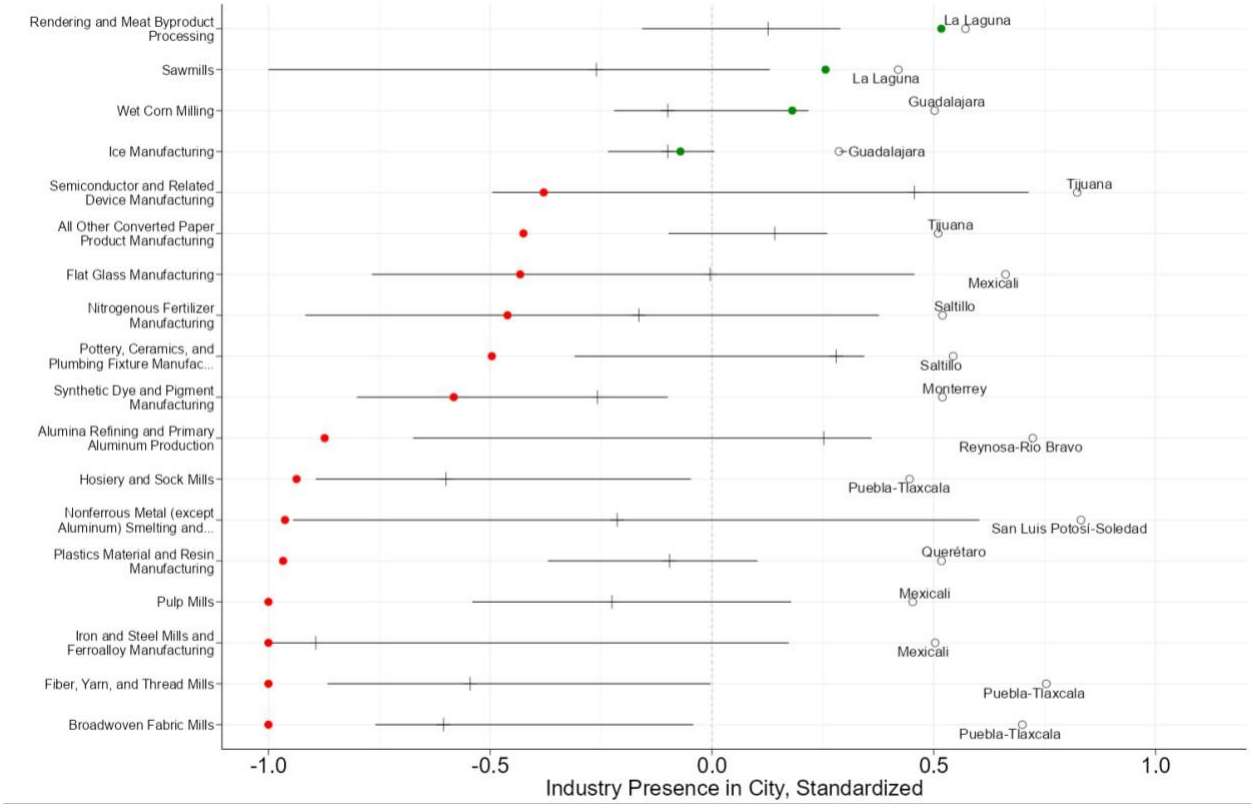


Source: Own elaboration based on Censo Economico 2018

Compared to its peer cities, Hermosillo is relatively further away from establishing a presence in powershoring industries. Figure 9 compares Hermosillo's presence in powershoring industries with that of peer cities. The line range on each industry shows the span between the 25th percentile to the 75th percentile of peer presence, while the circular point shows Hermosillo's presence in that industry. The point is colored green if Hermosillo is 'nearer' to this industry than the median peer, and colored red if it is not. The peer with the highest relative presence is also highlighted and labeled using a hollow point. The figure demonstrates that Hermosillo is below the presence of many of its peers with the exception of the three industries highlighted in the previous graph,[8] as well as ice manufacturing. In certain industries, such as flat glass manufacturing or nitrogenous fertilizer manufacturing, Hermosillo is closer to the median of the peer group. But in many others, it has no presence at all. This indicates that attracting investments in these industries may require significant coordination.

[8] Namely *animal slaughtering & processing*, *grain & oilseed milling* and *sawmills & wood preservation*.

Figure 9: Hermosillo's Presence in Powershoring Industries Relative to Peers



Source: Own elaboration based on Censo Economico 2018

An additional factor that will impact the feasibility of attracting investment from a specific industry into Hermosillo are its water needs. As previous work has highlighted, Hermosillo is water-constrained and the future availability of water could become a limiting factor to its economic growth (Fortunato et al. 2024). Companies with large water needs might find it challenging to secure an adequate water supply in Hermosillo in the future. While this is amenable to policy, it should be acknowledged by actors involved in investment promotion efforts. Several powershoring industries appear to have relatively high rates of water consumption (Figure A.2). Industries from the *"Paper and Wood"* cluster are amongst those with the highest water consumption per firm in the US.[9] This would likely make it challenging to attract investment from these industries to Hermosillo. While it is not impossible to overcome, the water intensiveness of targeted industries should be taken into account.

Powershoring industries not only provide growth opportunities but can also diversify Hermosillo's economy. This potential impact can be quantified with the complexity outlook gain, which is a measure of attractiveness indicating how many more diversification opportunities this industry could help to enable based upon

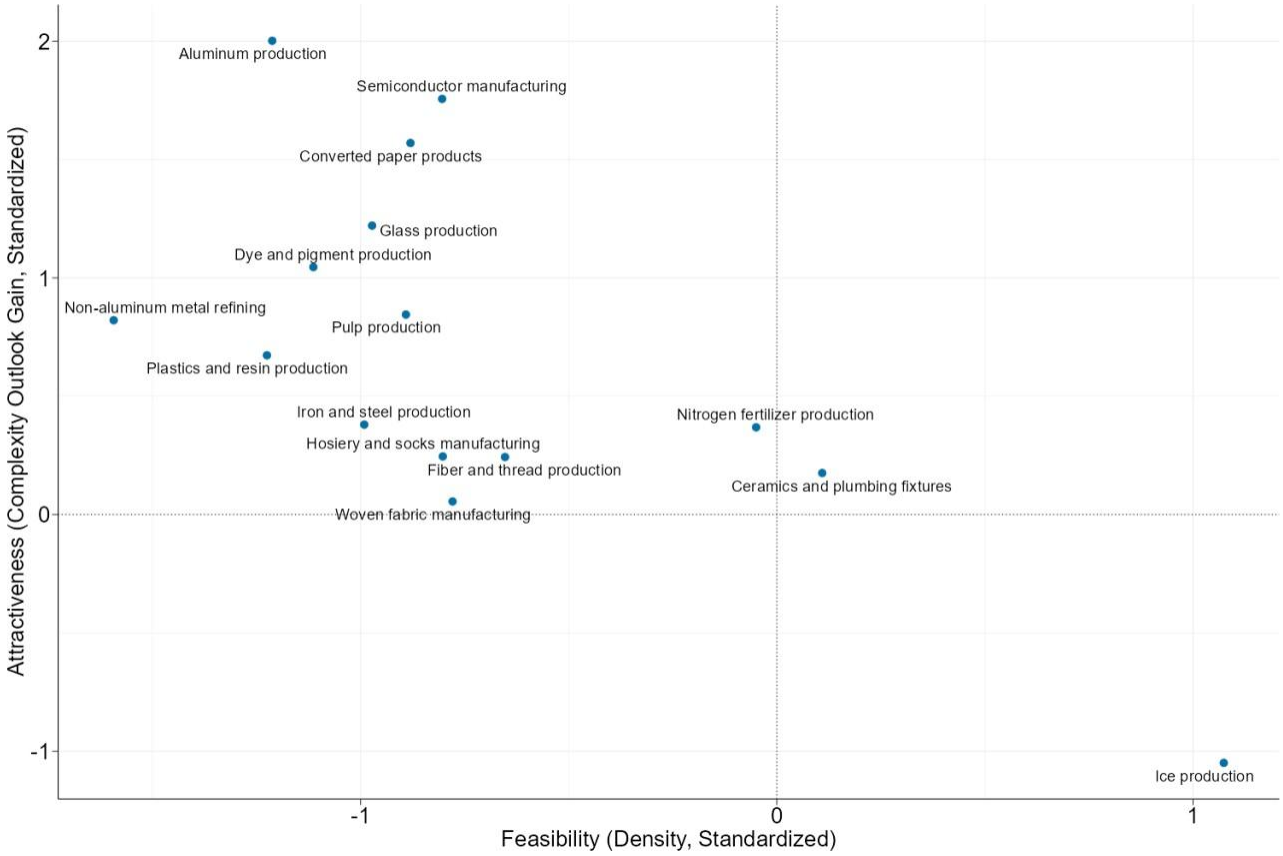
[9] Paperboard mills, newsprint mills and pulp mills are all well above the average water consumption per firm of the US manufacturing industry.

its connections in the industry space. Figure 10 shows how feasible and attractive powershoring industries are compared to all other industries in which Hermosillo has not yet established a competitive presence.[10] While an industry such as ice production is much more feasible than most other opportunities, it is not very attractive, given its low potential for diversifying the economy. Aluminum production and semiconductor manufacturing are on the opposite end of the spectrum — meaning that they are very attractive targets but rather far away from Hermosillo's current economic structure. Two industries that are relatively feasible and also still attractive are "nitrogen fertilizer production" and "ceramics and plumbing fixtures".

The insights from Figure 10 can inform the strategy of investment promotion in Hermosillo going forward, as they show how industries balance the feasibility and attractiveness trade-off. An industry such as *"ice manufacturing"* appears more feasible in Hermosillo but relatively less attractive. While "*aluminum production"* appears to be very attractive, but relatively far away from Hermosillo's current capabilities. The industries that appear to be both highly attractive and feasible at the same time are "*nitrogen fertilizer production"* and "*ceramics and plumbing fixtures"*. However, the position of the industries in this scatterplot does not necessarily prescribe whether or not they should be a target industry for Hermosillo. For example, it may still be reasonable to attempt *"aluminum production"* or *"semiconductor manufacturing"* companies even though they are further away from Hermosillo's current capabilities. Instead, it is important to be aware of this fact and to do follow-up work on the respective industries to understand the additional factors that could make Hermosillo more attractive to them. In the case of semiconductors, the investment push taking place in Arizona may improve Hermosillo's positioning through the possibility of entering the same value chains.

[10] Industries that Hermosillo has not yet "established a presence in" are industries for which the RCA < 1. The density and complexity outlook gain metrics have been standardized only using the data of these industries for Hermosillo.

Figure 10: Powershoring Industries & Hermosillo's Capabilities



Source: Own elaboration based on Censo Economico 2018

5. Building to a Strategy for Powershoring in Hermosillo

The analysis of powershoring industries and Hermosillo's positioning within them highlights opportunities for growth as well as some challenges. The complexity analysis has shown the feasibility and attractiveness of different powershoring industries with respect to Hermosillo's current productive structure. An additional aspect that impacts feasibility is the water intensiveness of industries given the importance of this factor in Hermosillo. This chapter will further explore the resulting growth opportunities of powershoring industries that are already present in Hermosillo (intensive margin) as well as those that are not present, hence would be new developments (extensive margin).

Growth on the Intensive Margin

While Hermosillo is present in only a few of the potential powershoring industries, it could take better advantage of growth opportunities in these industries. The industries in which Hermosillo has already established a competitive presence are *animal slaughtering and processing; sawmills and wood preservation;* and *grain and oilseed milling*. Growth in these industries will not necessarily offer new diversification

opportunities given that Hermosillo already has capabilities in these areas. But any growth in these industries would offer new economic opportunities for the city overall. Thus, growth of the already existing industries should not be neglected. We call this the growth at the *intensive margin.*

***Animal slaughtering and processing* is an established industry in Hermosillo given Sonora's large presence in meat production**. The energy intensive part of this industry is in the refrigeration of the meat as cold temperatures are required to preserve the meat. The consumer awareness of the emissions included in meat production has increased over time as beef is more resource-intensive than most other foods (Waite and Zionts 2022). While only a small part of the overall emissions in beef production stem from processing (2.7%), it is a significant opportunity for decreasing emissions of the industry as other parts are more difficult to decarbonize (Pelton et al. 2024).[11] Companies providing low-emissions processing services may be able to access a specific market willing to pay a premium for this. Powering *animal slaughtering and processing* with renewable energy may make Hermosillo attractive for companies servicing the US market given its potential willingness to pay for greener products.

Similarly, the *grain and oilseed milling* industry is already competitive in Hermosillo and could grow in the city due to powershoring dynamics. This is an industry which has seen FDI inflows from the US into Mexico (IMCO 2024). While the electricity usage from this industry can be switched to renewable sources it also requires combined heat and power (CHP). This makes full electrification difficult and may require carbon capture and utilization in a net-zero scenario. In today's market, there are already producers such as the Australian grain growers that market themselves as producing grains and oilseeds at low emissions (Sevenster et al. 2022). They explicitly state that their focus on low emissions is driven by "market preferences and financial investment advantages" (Grain Research & Development Corporation 2022). If Hermosillo makes use of its renewable energy potential it may be able to attract investment from companies that see this market opportunity in the *grain and oilseed milling industry.*

Growth on the Extensive Margin

Attracting new powershoring industries to Hermosillo offers growth as well as diversification opportunities for its economy. Several attractive powershoring industries exist for Hermosillo on the extensive margin. Figure 11 highlights the clusters that we will focus on in more detail. This selection is motivated by the fact that they are relatively less water-intensive and appear to offer more attractive upsides for Hermosillo. Industries within these clusters face different decarbonization challenges which will drive

[11] Modelled reductions from the processing stages make up 9% of the overall emissions reductions deemed feasible in the industry.

powershoring considerations. We provide an illustrative exploration of some of these challenges and opportunities in what follows.

Figure 11: Powershoring Growth Opportunities – Extensive Margin

Source: Own elaboration

The chemicals manufacturing cluster appears promising given recent investment announcements in Sonora and the existing industrial structure. The company *México Amoníaco y Urea* is planning a new fertilizer plant south of Guaymas with its production being powered by gas while another company announced ambitious plans to produce green ammonia in Sonora based on green hydrogen. While the direct viability of some of these projects is yet uncertain they indicate the potential that investors see to produce chemicals in Sonora. Hermosillo can leverage this to its benefit. The projects mentioned reveal information as first movers and local stakeholders learn what hurdles they need to clear to scale chemical manufacturing in Sonora. This is a process which local policymakers should be closely involved in as it will help gather information to attract new investments in this cluster.

The chemicals cluster also has other promising opportunities such as *plastics material and resin manufacturing* and *synthetic rubber manufacturing*. Plastic is a multi-purpose good that is included in many economic activities. Simply because of population and economic growth, plastic use is projected to triple by 2060 compared to a 2019 baseline (OECD 2022). However, the production of plastics is very emissions-intensive. Parts of its emissions intensiveness comes from the need for fossil fuel to produce the final product. These emissions cannot be reduced through electrification. But even outside of that the energy demands of the production process are significant. For example, powering the production of a common PET bottle reduces its emissions by 56% and in the case of PVC they even drop by up to 75% (Rubio-Domingo and Halevi 2022). Therefore, reducing emissions through switching to a greener energy supply will be attractive for plastics producers seeking to reduce their emissions. Hermosillo also has a domestic source of demand for these goods as several car manufacturing suppliers are active in plastic injection molding. This may indicate capabilities that are adjacent to the plastics production process. Other industries in the chemical manufacturing cluster (i.e. *artificial and synthetic fibers and filament manufacturing* and *synthetic dye and pigment*

manufacturing) appear to be relatively more water intensive, which could become a hurdle for potential investments from these industries.

The glass and ceramics cluster includes several industries that are attractive for Hermosillo and where some capabilities already exist. All industries in this cluster were below the average water industrial water consumption, except for *flat glass manufacturing*. This indicates that water availability may be less binding for the attraction of these industries. Beyond the availability of cheap renewable energy, a key component for this cluster are the inputs of raw materials such as silica, limestone, and clay. The proximity to the port of Guaymas and its capability to handle raw materials may be an important factor for the potential development of these industries. Moreover, the analysis shown in Figure 10 indicates that *ceramics and plumbing fixtures* is both relatively feasible and attractive and that *glass production* is a relatively attractive industry.

Another potentially attractive target within the glass and ceramics cluster is *mineral wool manufacturing*. Mineral wool is a widely used type of building insulation. It is an important component in enabling the transition to a climate-neutral building stock. However, the production process of it is very energy-intensive. A significant part of the emissions stem from the energy consumption dedicated to the melting process of basalt or slag (Krijgsman and Marsidi 2019). The melting process is one that is amenable to electrification through switching to an electric-arc furnace (ibid.). An example of action in this area is the multinational company *ROCKWOOL* announcing that they will half their emissions in a factory by switching to a an electric-melting technique powered by renewable energy (Grodan 2024). *ROCKWOOL* also has a presence in Mexico, and the development of its operations in Mexico may be helpful for Hermosillo's chances of entering this industry.

The semiconductor and electronics cluster also provides attractive growth opportunities for Hermosillo. Semiconductors are crucial for modern technological advancement, and the industry has gained substantial geopolitical and economic attention, especially in light of recent supply chain disruptions. However, their production is also both highly energy- and water-intensive. Clean room environments, lithography processes, and water chillers require large amounts of electricity (McKinsey 2022). These processes are part of the *front-end* of the semiconductor industry — the actual manufacturing processes. These are highly complex production processes which are also highly politically sensitive. The US government as well as other European governments have mobilized large subsidies to locate these manufacturing processes within their borders. Given these circumstances Hermosillo's opportunity will likely be in other parts of the supply chains.

The efforts of the US to develop its semiconductor industry are focused in Arizona which may open growth opportunities for Hermosillo. TSMC & Intel have announced

investments of close to $100 billion in fabrication plants in Arizona (TSMC 2024; Intel 2024). While the proximity and lower labor costs of Hermosillo opens opportunities, its potential for cheap renewable energy may be a further factor to consider. Both TSMC and Intel have announced emissions reduction goals of being net-zero by 2050 and 2040 respectively (Intel 2023; TSMC 2024). Reducing the emissions in their supply chain may be an avenue to reach these goals and Hermosillo could offer attractive options for that. The supply chain emissions are largely driven by silicone production, process gas production as well as from the metals production. Silicone production may, for example, be an opportunity. Sonora has existing silica reserves (Secretaría de Economia 2018) and its cheap renewable energy could enable a low-carbon processing of silicon.

6. Conclusion

Powershoring presents a unique opportunity for Hermosillo to align with the global shift toward decarbonization. By leveraging its abundant renewable energy resources, particularly solar power, Hermosillo could position itself as a key hub for energy-intensive industries seeking to reduce their carbon footprints. As the world transitions to clean energy, regions that can provide reliable, low-cost renewable energy will attract new industries, investment, and job creation. This report has shown that Hermosillo has the potential to capitalize on this shift, enabling its economic growth while contributing to the global effort to decarbonize industrial production. Its strategy should focus on leveraging its renewable energy potential for its own economic development instead of exporting it. Hermosillo's potential for growth through powershoring can be viewed through two lenses: the intensive margin, where existing industries can expand by adopting renewable energy, and the extensive margin, where new industries can be attracted to the region based on its renewable energy capabilities.

On the intensive margin, Hermosillo already has a competitive presence in several industries of the food & agricultural cluster. This includes animal slaughtering and processing, grain and oilseed milling, and sawmills and wood preservation. These sectors, which are critical to the region's economy, have potential for growth by transitioning to renewable energy and accessing markets with a green premium. For instance, the energy-intensive refrigeration processes in animal slaughtering or the combined heat and power needs of grain milling could be powered by solar energy, giving these industries a competitive edge in markets that increasingly value sustainability. Capitalizing on this shift could open up new export markets, especially in regions like the U.S. where demand for low-emission products is rising.

On the extensive margin, Hermosillo has the opportunity to attract industries that are not yet established in the region but could benefit from its renewable energy resources. The chemical manufacturing cluster, including plastics material and resin manufacturing, offers promising growth potential, especially as global demand for lower-

carbon plastics grows. Similarly, the glass and ceramics cluster, which includes industries like mineral wool production, could thrive in Hermosillo due to its renewable energy capacity and proximity to raw materials. These industries, which require high levels of energy for processes like melting or refining, could significantly reduce their emissions by relocating to a region with ample solar energy. Additionally, Hermosillo's access to land and its proximity to major markets make it an attractive location for these industries to set up new operations.

While Hermosillo is well-positioned to benefit from powershoring, several challenges must be addressed to fully realize its potential. The intermittency of renewable energy, especially solar, is a key obstacle. Solar power is dependent on daylight hours, and without complementary energy sources or storage solutions, it cannot provide a constant supply of electricity. This is particularly challenging for energy-intensive industries that require a stable and continuous power source. Green energy certificates are an option to claim that production processes are fully powered by renewable sources. The extent to which this is sufficient will depend on the respective companies and demands from their clients. For a continuous renewable energy supply, energy storage systems, such as battery storage, will be required and exploring interconnections with neighboring regions that have wind potential will be useful to balance the energy supply. Moreover, the distribution infrastructure will have to improve in order to meet the demands from energy-intensive industries.

To capitalize on the opportunities powershoring offers, Hermosillo must take proactive steps to address these challenges and enhance its appeal to investors. First, investing in green industrial parks that provide a dedicated supply of renewable energy, potentially coupled with energy storage solutions, may be crucial. These parks can offer industries a reliable source of renewable energy, making Hermosillo an attractive destination for powershoring investments. Additionally, the city should focus on targeting industries that are more easily electrified and align with Hermosillo's existing strengths, such as the glass, ceramics, and chemicals industries.

Powershoring opportunities should be a core part of Hermosillo's growth strategy going forward. Hermosillo's policymakers, industry leaders, and stakeholders must work together to align investments, infrastructure development, and policy strategies to leverage the city's renewable energy potential for its economic development. Strategic planning and targeted investment promotion will be key to showcasing Hermosillo as a prime destination for industries looking to decarbonize. By acting now, Hermosillo can solidify its position as a regional leader in green industrial development, contribute meaningfully to the global effort to combat climate change, and benefit economically from that process.

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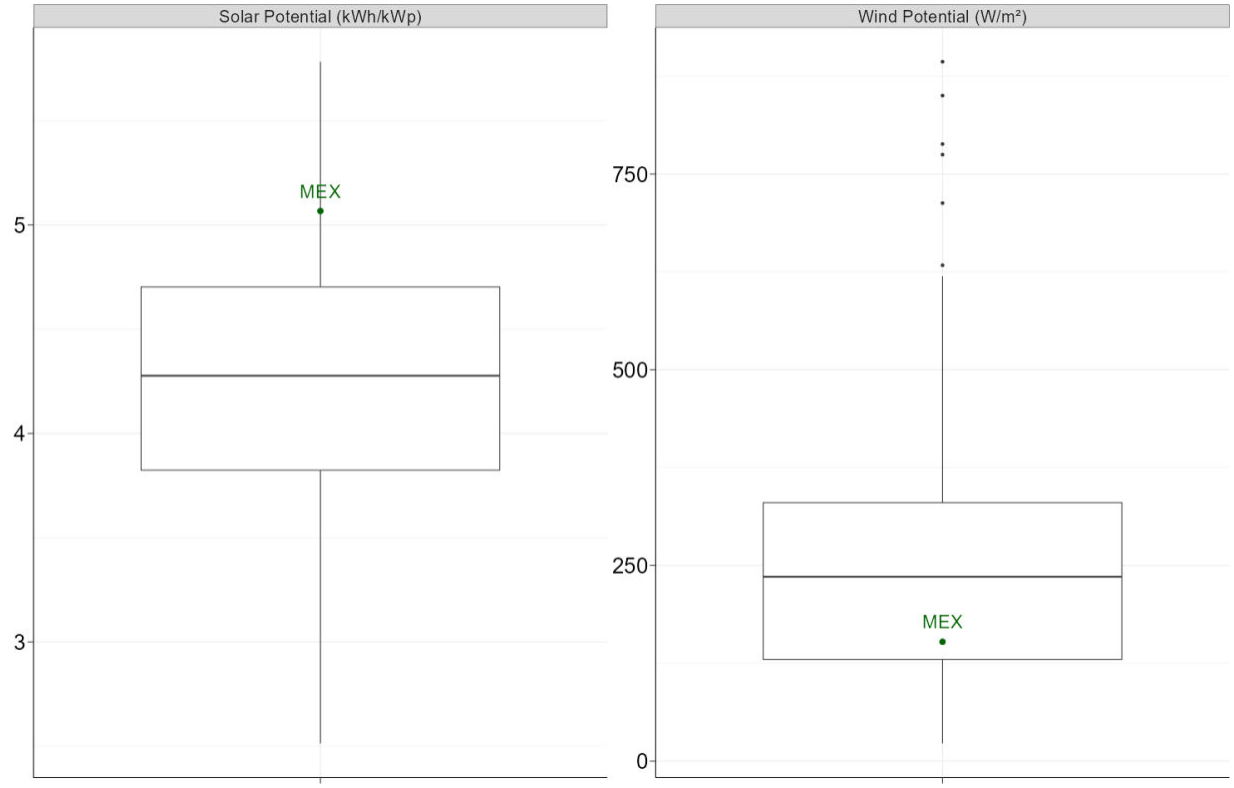
Appendices

Box 1: Main Concepts in Economic Complexity

A description of several of the variables in economic complexity methodology used in this report follows.

- *Revealed Comparative Advantage (RCA):* This is a place-product measure that captures the relative importance of a product in a place. Following the methodology of Balassa (1964), it is usually calculated as the ratio between the proportion of the product in the export basket of a place and the proportion of the product in world trade. If this relationship is greater than one, the place has a "revealed comparative advantage" in that product, which is equivalent to saying that the place produces the product more intensively than the rest of the world.
- *Distance & Density:* Distance is a place-product measure and corresponds to the sum of the proximities connecting a new good to all the products that country is not currently exporting. This value is normalized by dividing it by the sum of proximities between the new product and all other products. In turn, proximity is a product-product measure that is calculated as the minimum conditional probability that a country intensively exports one product given that it already intensively exports the other. Thus, if a country exports most of the goods connected to a product, then its distance to it will be short (close to zero). However, if the country only exports a small proportion of them, then its distance to it will be large (close to one). Density, in turn, is the inverse of distance (1-distance).
- *Complexity Outlook Gain (COG):* This is a place-product measure that quantifies the extent to which a location could benefit in opening future diversification opportunities by developing a particular product. Complexity outlook gain quantifies how a new product can open links to more, and more complex, products. Complexity outlook gain classifies the strategic value of a product based on the new paths to diversification in more complex sectors that it opens up. Complexity outlook gain accounts for the complexity of the products not being produced in a location and the distance or how close to existing capabilities that new product is.

Figure A. 1 Renewable Energy Potential – Global Distribution



Sources: (ESMAP 2019) (Davis et al. 2023)

Table A.1 – Energy Intensive Industries at the 4-digit SCIAN level

Energy Intensity and Revenue by NAICS Title

NAICS Title	RCA	Density	COG	Energy Intensity (%)	Export Intensity (%)	Avg. Revenue per Firm in the US (M USD)
Animal Slaughtering and Processing	3.14	0.63	0.00	4.61	25.73	48.2
Sawmills and Wood Preservation	1.69	0.66	0.00	2.93	15.47	10.2
Grain and Oilseed Milling	1.44	0.62	0.00	2.85	23.99	264.4
Beverage Manufacturing	0.87	0.69	0.00	7.77	10.71	2.8
Semiconductor and Other Electronic Component Manufacturing	0.45	0.50	2.55	3.68	89.06	70.3
Converted Paper Product Manufacturing	0.40	0.49	2.38	2.53	22.94	11.4
Glass and Glass Product Manufacturing	0.40	0.48	2.06	6.21	20.35	54.5
Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	0.37	0.58	1.29	8.15	15.11	37.6
Clay Product and Refractory Manufacturing	0.34	0.59	1.11	2.55	69.37	4.0
Basic Chemical Manufacturing	0.26	0.47	1.90	2.83	48.01	61.9
Alumina and Aluminum Production and Processing	0.07	0.46	2.77	18.09	46.33	132.9
Apparel Knitting Mills	0.03	0.50	1.18	3.04	24.48	7.8
Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	0.02	0.46	1.56	3.75	33.17	103.2
Nonferrous Metal (except Aluminum) Production and Processing	0.02	0.42	1.70	3.05	253.84	93.0
Fiber, Yarn, and Thread Mills	0.00	0.51	1.17	3.66	28.61	29.9
Fabric Mills	0.00	0.50	1.00	2.89	48.70	14.7
Pulp, Paper, and Paperboard Mills	0.00	0.49	1.72	3.89	82.29	361.2
Iron and Steel Mills and Ferroalloy Manufacturing	0.00	0.48	1.30	4.55	15.99	518.1

Source: Own elaboration based on US Economic Census 2018

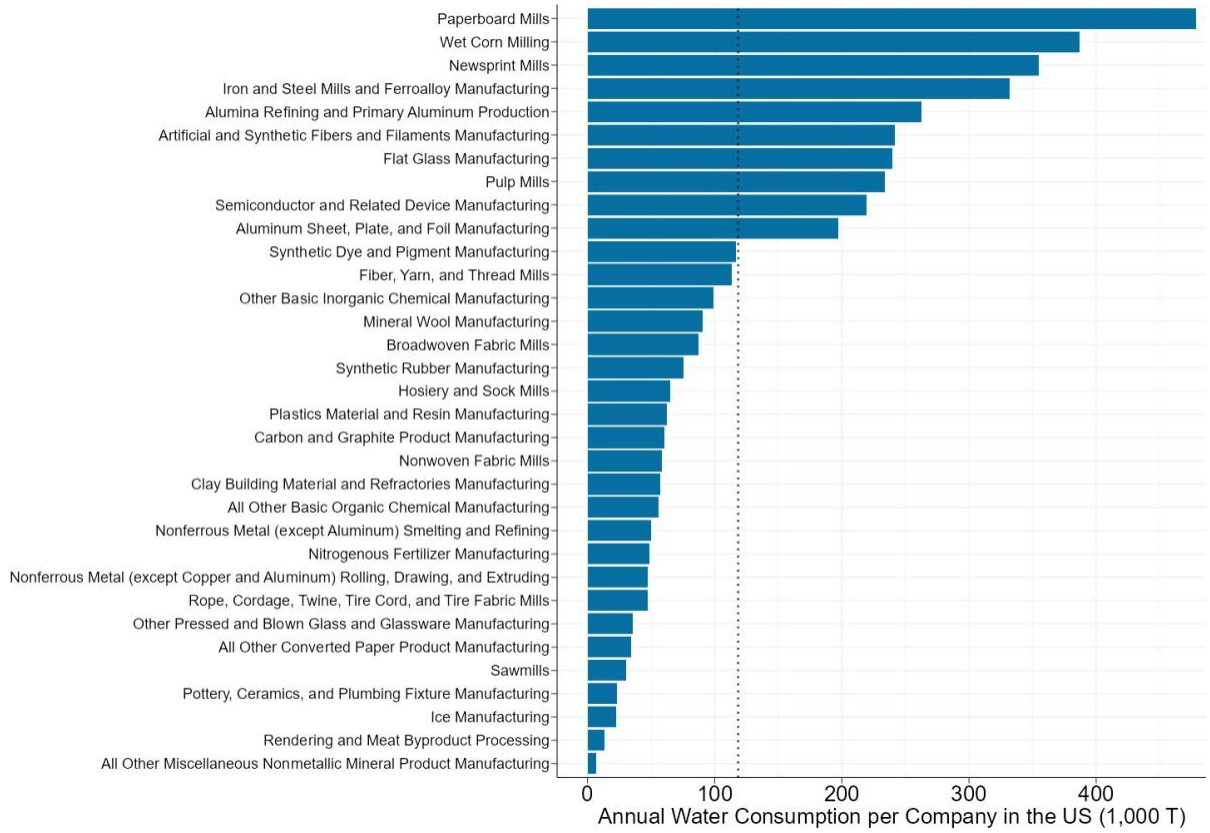
Table A.2 Powershoring Industries at the 6-digit SCIAN level

Energy Intensity and Revenue by NAICS Title

NAICS Title	Cluster	Energy Intensity (%)	Export Intensity (%)	Avg. Revenue per Firm in the US (M USD)
Newsprint Mills	Paper and Wood Products Manufacturing	21.84	31.48	110.0
Alumina Refining and Primary Aluminum Production	Metal and Mineral Processing	18.09	46.33	132.9
Nitrogenous Fertilizer Manufacturing	Chemical Manufacturing	8.15	15.11	37.6
Ice Manufacturing	Food and Agricultural Processing	7.77	10.71	2.8
Other Basic Inorganic Chemical Manufacturing	Chemical Manufacturing	7.18	44.10	84.4
Flat Glass Manufacturing	Glass and Ceramic Products Manufacturing	6.21	20.35	54.5
Other Pressed and Blown Glass and Glassware Manufacturing	Glass and Ceramic Products Manufacturing	6.07	50.74	9.0
Mineral Wool Manufacturing	Glass and Ceramic Products Manufacturing	5.04	16.17	36.8
Clay Building Material and Refractories Manufacturing	Glass and Ceramic Products Manufacturing	4.70	13.75	15.2
Rendering and Meat Byproduct Processing	Food and Agricultural Processing	4.61	25.73	48.2
Iron and Steel Mills and Ferroalloy Manufacturing	Metal and Mineral Processing	4.55	15.99	518.1
Paperboard Mills	Paper and Wood Products Manufacturing	4.31	16.46	528.0
Pulp Mills	Paper and Wood Products Manufacturing	3.89	82.29	361.2
Plastics Material and Resin Manufacturing	Chemical Manufacturing	3.75	33.17	103.2
Semiconductor and Related Device Manufacturing	Semiconductor and Electronics Manufacturing	3.68	89.06	70.3
Fiber, Yarn, and Thread Mills	Textile and Fabric Manufacturing	3.66	28.61	29.9
Artificial and Synthetic Fibers and Filaments Manufacturing	Chemical Manufacturing	3.60	33.02	62.2
Carbon and Graphite Product Manufacturing	Metal and Mineral Processing	3.45	40.80	28.8
All Other Basic Organic Chemical Manufacturing	Chemical Manufacturing	3.42	41.13	125.7
Nonferrous Metal (except Aluminum) Smelting and Refining	Metal and Mineral Processing	3.05	253.84	93.0
Hosiery and Sock Mills	Textile and Fabric Manufacturing	3.04	24.48	7.8
Rope, Cordage, Twine, Tire Cord, and Tire Fabric Mills	Textile and Fabric Manufacturing	3.03	21.22	12.4
Sawmills	NA	2.93	15.47	10.2
Broadwoven Fabric Mills	Textile and Fabric Manufacturing	2.89	48.70	14.7
Wet Corn Milling	Food and Agricultural Processing	2.85	23.99	264.4
Synthetic Dye and Pigment Manufacturing	Chemical Manufacturing	2.83	48.01	61.9
Aluminum Sheet, Plate, and Foil Manufacturing	Metal and Mineral Processing	2.68	24.71	315.8
Synthetic Rubber Manufacturing	Chemical Manufacturing	2.63	65.95	59.8
All Other Miscellaneous Nonmetallic Mineral Product Manufacturing	Glass and Ceramic Products Manufacturing	2.62	12.37	18.3
Pottery, Ceramics, and Plumbing Fixture Manufacturing	Glass and Ceramic Products Manufacturing	2.55	69.37	4.0
All Other Converted Paper Product Manufacturing	Paper and Wood Products Manufacturing	2.53	22.94	11.4
Nonwoven Fabric Mills	Textile and Fabric Manufacturing	2.52	29.39	36.9
Nonferrous Metal (except Copper and Aluminum) Rolling, Drawing, and Extruding	Metal and Mineral Processing	2.51	77.67	31.1

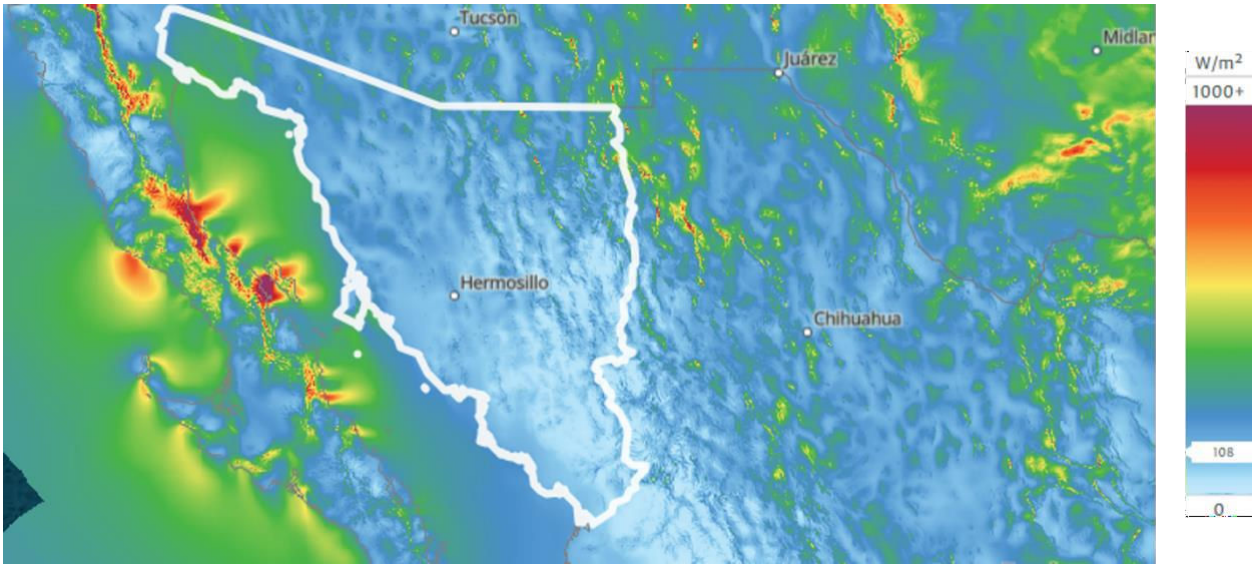
Source: Own elaboration based on US Economic Census 2018

Figure A.2 Water Intensiveness of Powershoring Industries



Source: Author's calculations based on data from Yang et al. 2017 and the US Economic Census 2018

Figure A.3 Wind Power Potential in Northern Mexico



Source: (Davis et al. 2023)