

Developing photovoltaic power plants in Latin America

Selecting the country market and internationalization strategy



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Abstract

The point of departure of this thesis is the growing demand for renewable energy sources across the world including solar photovoltaic power generation. The work is focus on Latin America, as this region has substantial potential for solar energy exploitation due to high levels of solar irradiance. The analysis covers which market variables that is of high importance to private developers of large-scale photovoltaic power plants. Building on the identified market variables a comprehensive market assessment of Argentina, Brazil, Chile and Mexico has been conducted. In the second part of the thesis, the analysis digs deeper into the competitive picture of the Chilean solar industry and discusses the different entry strategies that new market entrants can follow in this specific market.

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1 Introduction

With the Paris agreement, 196 nations signed a legally binding treaty to limit global warming to below 2 degrees Celsius. In order to accomplish this target, governments, municipalities and private companies across the globe increasingly need to adapt their energy supply from fossil fuels to renewable energy sources like wind, solar and hydropower (United Nations, n.d.). The transition from fossil fuels towards renewable energy sources means that there is an increasing number of electricity auctions and public tenders globally within biofuel, wind-, solar- and hydropower. Solar photovoltaics (PV) installations accounted for more than half of the total share of renewable energy volumes auctioned in 2017-2018 (IRENA (A);, 2019, p. 4). The competition for the development of those power plant contracts includes domestic companies as well as foreign-based companies.

However, the market for renewable power plants is complex. Variables such as geography, climate, government policies, infrastructure, subsidizes, labour cost and culture are just some of the elements that foreign companies need to consider before bidding on tenders within this industry. Much of the existing research is focused on how local and governmental authorities can design effective RE programs, but there seem to be a lack of literature that takes the industries point of view.

In this thesis, a market assessment will be conducted for the PV Solar power plant industry in Latin America (LATAM) based on identified key variables that are applicable for this specific industry. Based on this analysis, the thesis aims to discuss internationalization strategies hereunder entry modes for foreign companies who wish to enter the local Solar PV industry.

In order to limit the research field the focus will be on developers within ground mounted large scale PV Systems with a minimum capacity of 1000kWp. Small residential PV systems like rooftop installations or water floating PV systems will not be the scope of this assignment (Global Solar Atlas, 2021).

1.1 Background

According to the International Renewable Energy Agency (IRENA), many of the top markets for investment in renewable energy are located in Latin America due to the favourable amount of solar radiation. For example, The U.S. Department of Commerce has ranked Brazil, Chile

and Mexico among the top markets in the world for U.S. companies and exporters of renewable energy (Palma et al., 2020).

With this thesis, I want to understand what the most important variables are that PV power plant developers have to consider before they enter foreign markets. Furthermore, I want to apply this research to the Latin American market and identify which market has the best potential for foreign-based companies that develop, build and operate PV plants.

Important variables for PV developers are obviously linked to geographic and climatic circumstances for exploitation of solar energy. In this aspect, many of the countries in South America have favourable conditions due to a relatively high solar radiation (Global Solar Atlas, 2021). However, there are also several commercial aspects that are relevant to consider in order to evaluate whether or not a market is attractive for companies who want to build and potentially also operate PV power plants in LATAM. Such a comprehensive analysis, which includes several variables, makes an important contribution to our knowledge of solar power market conditions.

1.2 Problem statement

The development of PV solar projects in LATAM is gaining ground in terms of quantity and scale (Bellini, 2018). The execution of projects in this industry typically last several years and if the company decides to keep the assets and sell the electricity to utilities or private companies through so called power purchase agreement (PPA), the contractual relationship and economic impact on the company can last up to 25 years (*Solar Power Purchase Agreements*, n.d.). By nature, this means that the companies are taking a great deal of risk when they internationalize into new markets. Therefore, it can be asserted that foreign companies could benefit from a more thorough market assessment and market selection process before they bid on specific tenders in LATAM. As the demand for PV power generation rises and the number of potential projects that companies can participate in increases, those companies also gain the advantage of being able to select more carefully in which specific markets they want to be. This has not always been the case in the relatively immature PV industry where companies have been forced to participate in the relative few projects available in the LATAM market.

In the existing literature, much research on solar PV power plants have been focused on solar radiation, electricity prices and the composition of the electric grid. While these variables can

serve as important indicators to whether it is feasible for governments to promote and invest in solar power initiatives, they do not provide a basis that will enable private PV developers to determine whether a specific market will be attractive and profitable for their company. The existing studies lack the consideration of macroeconomic variables such as barriers to foreign direct investment (FDI), exchange rate risk and long terms government incentives to name a few. These variables are very important for the contractor/developer but can be difficult to assess. The reason for this is that existing research in the commercial area of this subject have been focused on renewable energy on a general note rather than specifically on the circumstances that apply to the solar PV industry in LATAM. It is this research gap that will be covered in this study.

1.3 Research question

In order to address this gap in the literature, the study answers two research questions, and is guided by four objectives.

Research questions:

- 1. What are the most attractive market(s) in Latin America for foreign-based solar PV power plant developers, and which market variables are the most important to consider as part of the country market selection process?*
- 2. How can a PV developer build an internationalization strategy for the specific identified market(s)?*

The objective with this study is to analyse what the most attractive market(s) in LATAM for foreign-based PV developers in the ground mounted large-scale segment are, and to identify the key variables that those companies need to consider as part of their internationalization strategy. The thesis will be guided by the following sub-objectives:

1. To provide a list of key variables, based on industry characteristics, that PV markets can be measured upon to evaluate their attractiveness.
2. To conduct a market screening of LATAM. The purpose of this is to identify a shortlist (3-4 countries) for further in-depth market analysis.
3. To analyse the markets on the shortlist based on the identified key variables and from this, to identify the most attractive market(s). This is the market selection.

4. To provide strategic recommendation on how a PV developer can prepare their internationalization strategy for that specific market.

The study's focus is on internationalization opportunities for foreign private companies - not environmental reflections or emerging markets.

2 Literature review

During the past years a large share of the research conducted within solar power generation have been based on natural science disciplines like geography and physics. Research within these disciplines have been mostly concerned with how the technologies can become more efficient and maximization of power output.

Singh (2013) has made a contribution in which the progress within the various solar power technologies (Solar heat, Solar photovoltaics, solar thermal electricity and solar fuel) is put under review (Singh, 2013).

Pravalié et al. (2019) offers a comprehensive study on the natural geographic conditions for solar radiation in different areas of the world in which they identify the locations that offer the best geographic potential for PV exploitation based on geostatistical measures (Právělie et al., 2019).

Concerning market research within the field of utility scale PV plants much research has been conducted by industry associations such as the international renewable energy agency (IRENA) and Solar power Europe. In 2016, IRENA published a report on the renewable energy market in Latin America. This report has a wide scope and focuses on marine, wind, solar, small hydro power, geothermal, solid biofuel and liquid biofuel (IRENA, 2016, p. 14). While reports made by organizations like that can provide background knowledge about local markets, it is also important to bear in mind that those organizations have an agenda that seeks to promote renewable energy sources, and therefore, it can be problematic for private companies to base their investment decisions purely on data from those organizations.

Mastropietro et al. (2014) have conducted research on electricity auctions in South America in which they focus on Brazil, Colombia, Peru, Chile, Argentina and Uruguay. This study focuses more on the regulative side of the electricity auctions and how the requirements for these auctions have changed over time to become more long-term based (Mastropietro et al., 2014).

Finally, Chapman (2021) offers insight within the field with his study on PV markets in Brazil, Mexico, Chile and Argentina. This is perhaps the study that comes closest to the objectives of this study. The study is focused on the electricity sector, support mechanisms and barriers affecting growth in each of the four markets. However, the research is on an explanatory level and the objective of his study is not to come up with specific recommendations for foreign companies who want to enter the PV market in LATAM. As the author states: "*Future studies could offer a quantitative analysis of the solar industry in these four countries, provide rankings and perform a more extensive review*" (Chapman, 2021, p. 47). Based on Chapman's suggestions, this thesis addresses an important gap in the literature by identifying key variables and analysing each market according to those.

2.1 Energy supply matrix

The term energy matrix is used to describe the composition of energy resources in a system. When referring to countries' energy matrix they are often divided into renewable energy resources such as hydro, wind, solar, geothermal and biomass and non-renewables or fossil fuels such as carbon, oil and natural gas (Howell, 2021). Whether nuclear power should be categorized as a renewable or non-renewable is heavily debated. While nuclear power technically is not a renewable due to the fact that it requires uranium or other minerals that will eventually run out, there seem to be a consensus that it is a better alternative compared to fossil fuels like coal, oil and gas (Veazey, 2020).

One main variable that affects countries or geographic regions' energy matrix is the availability of resources nationally or the capacity need for importation. Other important variables are the type of energy needed, geopolitical considerations, geography, economy and last but not least social and ethical considerations (Howell, 2021).

In a study on fossil fuel prices and policy implications for Latin American and the Caribbean, Griffith-Jones et. Al (2017) found that fluctuating oil prices have a strong correlation on investments in renewable energy in LATAM. Further, they found that a sharp decline in cost of renewables, and especially solar PV generation, have driven private investments in Latin America. However, large fossil fuel subsidies in some major oil producing countries have encouraged substantial investment in the oil sector and increased consumption of oil. The authors also found that sharp drops in oil prices pose a risk of disrupting continued investment in renewable energy. They highlight the year 2014 as an example of a heavy reduction in oil

prices (Griffith-Jones et al., 2017). Since then, we have experienced a similar decrease in oil prices during the breakout of Covid-19 in 2020 (Nguyen & Arezki, 2020).

It is however interesting that the authors also highlight that the dramatic declines in oil prices could be an ideal opportunity for national governments in LATAM to lift subsidies to the oil and gas sector without causing a major increase in electricity prices (Griffith-Jones et al., 2017, p. 44). The composition of the energy matrix is relevant for PV developers to be aware of since other energy sources and generation methods represent substitute products/services. Therefore, PV developers will experience competition from those actors in the market.

2.2 Entry barriers and drivers to FDI

According to the OECD the definition of foreign direct investment is:

A category of cross border investment in which an investor resident in one economy establishes a lasting interest in and a significant degree of influence over an enterprise resident in another economy. Ownership of 10 percent or more of the voting power in an enterprise in one economy by an investor in another economy is evidence of such a relationship (Foreign Direct Investment (FDI), n.d.)

Some of the widest acknowledged determinants of FDI are market size, growth potential, openness, exchange rate valuation, clustering effects, political stability and institutions (Walsh & Yu, 2010).

Apart from those very broad determinants, Keeley and Matsumoto (2018) have conducted a study on the determinants of foreign direct investment in developing countries applicable to solar- and wind developers. Based on a questionnaire conducted by 21 experts within solar and wind energy they conclude that traditional FDI determinants such as exchange rate volatility, access to land and efficient and transparent administrative procedures are very important determinants. More specific key determinants to the solar and wind industry include priority access to the electric grid, feed-in tariffs and auctions. However, out of all the determinants identified in Keeley & Matsumoto's study, the respondents ranked exchange rate volatility risk as the most important determinant in solar and wind developers' decision-making process. The main reason for this is that solar- and wind projects typically have a very long pay-back period. Exchange rate risk, which is often connected to unstable currencies, affects future returns in the projects but also the cost of financing the projects.

Other factors that were highlighted by the questionnaire respondents but with less relative importance include access to local finance, political risk, natural resources, effective law enforcement, labour costs, tax-incentives, renewable energy certificates & renewable portfolio standards (REC & RPS), absence of local content requirements (LCR), technical standards, renewable energy targets, development plan and social acceptance (Keeley & Matsumoto, 2018).

2.3 Internationalization theory

Companies that wish to internationalize their organization can pursue different international strategies hereunder international strategy, global strategy, multidomestic strategy and transnational strategy. These four different strategies have different approaches to costs and efficiency on one side and on the other side responsiveness towards local customer preference and local market conditions. For example, the global strategy emphasises low cost and high efficiency at the cost of local responsiveness to the local market. In the other end a multidomestic strategy has a high level of local adaptation to specific market conditions but the cost related to this adaptation is higher (Mellahi & Frynas, 2015).

Some of the main theories within internationalization of companies include the Uppsala internationalization model, transaction cost theory, the network model, the OLI paradigm and born globals (Hollensen, 2020, pp. 77–78). The approach in this thesis is in line with Penrose, Prahalad and Hammel who suggested that companies' marketing focus is combined by the company's core competences and the opportunities in the external environment (Hollensen, 2020, p. 77). This thesis is very much focused on the opportunities in the external environment. It is assumed that a main motive of internationalization for PV developers is resource seeking. If PV developers can access better solar resources abroad compared to their home market, they could potentially lower their cost through better efficiency and achieve greater profits – at least if the remaining variables in the new environment do not increase operation cost significantly.

The theoretical approach is also in line with Dunning's ownership-location-internationalization approach and especially the view that locational advantages must be present in the foreign market such as labour, energy, materials, components and transport (Hollensen, 2020, p. 78).

2.4 Porters five forces

The Porters five forces framework presented in Michael Porter's article from 1979 "*How competitive forces shape business strategy*" is a framework that can help understand the competitive forces that surround specific companies or industries.

The framework consists of *industry rivalry* that refers to the existing rivalry within a given industry. Second, the *bargaining power of suppliers*, which refers to the competitiveness that the company faces from its suppliers. Third, the *threat of new entrants* is concerned with the possibility and ease for new companies, which offer the same product or service, to enter that specific industry. Fourth, the *threat of substitutes* covers the likelihood of competitive pressure from companies that offer a substitute product or service. The fifth competitive force is the *bargaining power from buyers* and customers which cover the pressure that the buyers might have over a certain company (Porter, 1979). The competitive framework is a valuable tool to evaluate the competitive picture and design effective strategies, which can help to reduce the threat from other industry participants.

2.5 Hofstede's cultural dimensions

In the 1970s Geert Hofstede developed his theory on cultural dimensions in work-related values that was since published in his book: *Culture's Consequences: International Differences in Work-Related Values* (Hofstede, 1984). The cultural dimension framework consists of 5(+1) cultural dimensions of national culture. These dimensions include *power distance*, which refers to the degree of which power is distributed equally in society and groups. *Individualism vs collectivism* refers to how members of a society see themselves in relation to the group and if they are "I" oriented or "we" oriented. *Masculinity vs. Femininity* refers to the values of a society that can be oriented towards achievement, heroism and material awards or on the other side values that include cooperation, modesty and caring for the weak. *Uncertainty avoidance* covers how society members see the future and to what degree they will try to control it. *Long-term orientation vs short-term normative orientation* refers to how society's deals with challenges based on links with the past. *Indulgence vs. restraint* covers how societies values human drives related to having fun and enjoying life (Hofstede et al., 2010). The cultural dimensions is one of the most widely accepted models to cover cultural characteristics, and are therefore often used in the preliminary process of preparing companies for international tasks.

2.6 Entry mode strategy

When organizations want to internationalize and bring their product or service to the market in a foreign country, their strategy can rely on different entry modes including trading entry modes, contractual entry modes and investment entry modes. Trading entry modes include direct export, indirect export, piggybacking and countertrade. Contractual entry modes include licensing, franchising, management contracts and turnkey contracts. In the investment category, companies can choose to internationalize through wholly owned subsidiaries either by building new facilities representing greenfield investment or by acquiring existing facilities representing brownfield investment. Other options include strategic alliances, joint ventures, or mergers and acquisitions. The choice of entry mode will depend on several factors including local business environment, the company's own resources, experience, amount of control and the size of the market (Wild & Wild, 2020, pp. 350–364). While the trading entry modes is most often used on a global scale these arrangements are not suitable for intangible companies like Solar PV developers. Therefore attention, for this part, will be drawn to contractual and investment entry modes.

3 Methodology

The methodological design in this thesis is built on a mixed methods approach. The mixed method approach allows researchers to apply both quantitative and qualitative data collection techniques. The research follows a pluralist view on research methodology that is flexible towards selection of methods. This view contradicts with the unitarist methodology view, which will usually have a preference towards one methodological discipline and is less tolerant towards other methods and mixing them (Saunders et al., 2019, p. 181).

More specifically, the research design can be described as a sequential multi-phase design. This research design allows multiple phases of data collection and analysis. This design allows researchers the chance to collect qualitative data followed by quantitative data and then go back to a qualitative phase again (Saunders et al., 2019, p. 182).

The consideration behind the methodological choice is that the research field is broad, complex and that the author has limited knowledge about the industry and especially the technical aspects part of it. To be able to go back and forth between qualitative and quantitative methods has been important in order to understand the industry, as the analysis and its conclusions show. For instance, the interviews conducted (representing qualitative methods) were crucial for understanding and selecting the specific variables that each market should be measured upon.

In the analysis of each variable, quantitative data has been important to measure each market on several variables. The following, elaborates on the specific methods used and the data collected through each method.

3.1 Qualitative data

The qualitative method applied in this thesis is interviews. There are many forms of interviews that can be used depending on structure, participants and number of people. Research that undertakes exploratory or explanatory elements in the research design often include in-depth or semi structured interviews. These interview forms allow the researcher to understand causal relationships between variables. Furthermore, where it is important to understand the reasons for decisions, attitudes and opinion, researchers are likely to conduct in-depth or semi structured interviews (Saunders et al., 2019, p. 444).

The interviews conducted in this research can be categorized as unstructured. However, the interviews did both have elements of what Saunders et. Al refer to as the semi-structured interview and the in-depth interview form.

For the interviews, some questions and topics were prepared. Some were open ended and encouraged the interviewees to “think out loud” and discuss topics freely. The semi-structured interview enhances the quality of the study in several ways. First, it allowed the researcher to gain a better understanding of the technical requirements and circumstances that surround PV-developers’ decision making, which ultimately led to the assessment of the most important variables that need to be considered when developers enter foreign markets. Apart from that, the interviewees’ own experiences in the Latin American markets were particularly useful for the evaluation of some specific variables including the electrical grid and the barriers to trade.

All interviews did also contain elements of the in-depth interview form. This interview form is particularly useful for the exploration of new themes that emerge from the conversation and allows interviewees to share their experiences, behaviour and beliefs (Saunders et al., 2019, pp. 438–439). Towards the end of interviews participants were encouraged to share insights, and experiences from projects that had emerged during the conversation.

All interviews were conducted with industry practitioners and the duration was 45-90 minutes each. The interviews were conducted through MS Teams due to participant’s different individual locations.

Qualitative data from secondary sources have also been applied to the research. Sources of qualitative data include academic journals, newspaper articles and market assessment studies.

3.1.1 Interview overview

Participant	Position	Company	Company origin	Company type
Interview participant 1	Commercial manager (Renewables)	EFACEC power solutions	Portugal	RE developer and component manufacturer
Interview participant 2	Technical Specialist Renewables and Storage	Advisian (Worley Group)	Australia	Consulting firm
Interview participant 3	HSSE Advisor	Scatec	Norway	RE developer
Interview participant 4	Technical project manager	Scatec	Norway	RE developer

3.2 Quantitative data

Quantitative data from secondary sources have also been applied in this thesis. This data has been effective for the evaluation of some variables, particularly concerning tariff-levels and exchange rate risk. Besides that, numerical data concerning construction costs, solar irradiance levels, energy prices and energy supply mix has been used to gain a better understanding of the industry.

The selection of datasets has been based on criteria such as the reliability of the source, who was responsible for the collection of the data, when was the data collected and how the data has been analysed. Attention has also been drawn to any potential conflict of interest and bias that organizations or individual authors might have.

The market selection analysis is based on a quantitative scheme where each variable has been given a weighting in percent, representing the variable's importance for the market selection process. Each of the identified countries on the shortlist have been given scores ranging from 1-10 on each of the six variables. The highest achievable score is 10, suggesting that the market is very attractive, while 1 on the other side constitutes a very unattractive market for foreign companies.

3.3 Research strategy

First, a short list of four country markets will be identified and they will be subject of an in-depth market analysis. The shortlist will be based on simple market size indicators. Then a brief account of the specific industry characteristics that are applicable for PV power plant developers will be given, hereunder supply chain structures and raw materials used during the construction phase.

The different variables that the countries on the shortlist will be measured upon will be based on industry characteristics and interview contributions from practitioners. The different variables can be found within macro variables such as country risk, general regulation characteristics, market traits and country specific characteristics. I will grant each variable a weighted score meaning that all variables will not have the same level of importance. This analysis should allow to select 1-2 country markets that will be the most attractive markets for PV developers to bid for future contracts.

Finally, it will be discussed how PV developers can prepare their internationalization strategy for the identified market(s). This discussion takes competitive forces within the industry into consideration, hereunder bargaining power of buyers, suppliers, substitutes, new entrants and existing competitors. Finally, the different modes of market entry will also be discussed under chapter 17. The discussion should result in concrete recommendations that could be valuable to industry practitioners.

4 Defining a shortlist of markets

The purpose of the first phase of the market selection process is to define a shortlist consisting of four country markets that will be subject to further in-depth analysis of specific market variables. The selection of the country markets in the shortlist is based on Chapman's (2021) study as well as the market size and solar irradiation levels.

As it is the case with product markets, the market size is worth considering when building power plants. The size of the country and the total electricity consumption is essential for the demand for new PV plants in the future. The development of new PV plants requires comprehensive investments from private companies or local utilities and the construction period will typically last several years, which means that there is a natural limitation to the number of potential projects that PV developers can bid and compete for. In a small country

this could mean that there might be periods where there are no projects under construction at all and no future projects in the pipeline. These country markets might be less attractive for foreign companies. Partly because the companies will still face transaction costs connected to doing business in a new market, but also because potential interruptions and pauses in between projects might affect the learning curve negatively compared to larger markets that continuously have demand for new projects.

Solar radiation distribution is another crucial aspect when assessing whether or not a market is attractive for Solar PV development. A high solar radiation means that each solar cell is going to produce more electricity making the entire plant more efficient. Hence, the level of solar radiation has a direct impact on the possibility to recover investments in solar projects (Právělie et al., 2019, p. 694). Moreover, the solar radiation level and climate conditions are likely to affect government and municipalities' decision regarding whether to invest in solar PV installations or other renewables.

4.1 Market size

A simple indicator on the market size for electricity generators is the annual electricity production of the markets. According to BP's *statistical review of world energy 2021* Brazil was the country with the highest annual electricity generation in the region in 2020 with 620 annual terawatt hours (TWh) of generation followed by Mexico (313 TWh), Argentina (143 TWh), Chile (84 TWh), Colombia (75 TWh) and Venezuela (58 TWh) (BP, 2021). According to Enerdata's 2020 report Venezuela's electricity generation is substantially higher with 93 TWh (Enerdata, 2020). Apart from the case of Venezuela, the numbers remain similar across various sources.

While these numbers show the total consumption of electricity, they do not offer information about the industry for PV solar generation in each country.

To assess the foothold that solar PV installations have gained in each market, the total installed capacity for PV installations and newly installed capacity during 2020 will be compared. For this purpose, IRENA's renewable capacity statistics has been used. The numbers shows that in 2020, the leading country in the region in terms of total installed solar PV capacity was Brazil with 7881 Megawatt (MW) followed by Mexico 5630 MW, Chile with 3106MW, Argentina with 764MW, Honduras 514MW and El Salvador with 429MW (IRENA, 2021, pp. 24–25).

When looking at newly installed capacity during 2020 the trend is similar with Brazil being the regional leader in front of Mexico, Chile and Argentina. It is however also worth mentioning that the installed capacity of the LATAM countries is still very far from the global leaders which are China (254.355MW), USA (75.572 MW) and Japan (67.000 MW). In fact, Brazil is the only country in the region which is found in the global top 15 of installed PV capacity (IRENA, 2021, PP. 23-26)

When population numbers and overall electricity consumption in the society is taken into consideration the image of global leaders within Solar PV generation changes a lot. In fact, in 2020 Honduras was the country in the world with the highest share of national electricity consumption coming from Solar PV installations with 12,9% and Chile was 5th on the list with a 9,1% share stemming from Solar PV generation. However, since Honduras is a very small market in terms of overall size it will not be part of the shortlist and subject to further analysis.

4.2 Solar irradiance

In order to evaluate the potential for exploitation of solar energy, data on solar irradiance and radiation levels from the global solar atlas has been studied – a card extraction for LATAM is available in figure 1. Furthermore, Právělie et. al.'s (2019) study on global solar radiation named “*Spatial assessment of solar energy potential at global scale. A geographical approach*” has provided valuable insights. In this study, the authors have mapped the land surface of the planet based on the level of GHI (Global horizontal Irradiance) and DNI (Direct normal Irradiation). The authors use seven different potential classes to range the solar radiation ranging from poor to superb (Právělie et al., 2019).

The authors found that Mexico has the largest potential regarding GHI in North- and Central America with more than 1.8 million km² of land in the excellent, outstanding and superb classes (Právělie et al., 2019, p. 697).

Out of South America's 18 million km² approximately 60 percent of the landmass qualifies with the excellent, outstanding and superb classes. The radiation levels are significantly lower in the North and the Amazon region where high levels of cloud cover affects the radiation levels in a negative way. The superb potential class is dominant in the area of the Atacama Desert that has some of the highest radiation levels globally. Five states have extensive areas with excellent, outstanding and superb potential for PV Solar exploitation. Argentina covers

the largest area with 2 million km². Second is Brazil with 1.9 million km² in the three best potential classes. In Chile the number is 400000 km², Peru 300000 km² and Bolivia 270000 km² (Prävālie et al., 2019, pp. 702–703).

Based on the market size and existing deployment of Solar PV technologies combined with the solar irradiance levels, Brazil, Mexico, Chile and Argentina have been chosen for the market selection shortlist. Those four country markets will be subject to further in-depth analysis of the market attractiveness.



Figure 1: Figure 1: Specific photovoltaic power output (Global Solar Atlas)

5 Cost structures in PV utility scale

The cost of building utility scale PV plants can be separated into three main cost categories: Hardware cost, Installation cost and soft cost. The global trend is that the total costs of building utility scale plants are decreasing rapidly. This trend is driven by lower module prices, because of improved efficiency. Between December 2009 and December 2019 the prices of crystalline silicone modules sold in Europe declined between 87-92% (IRENA (A):, 2020, p. 62). This

development is interesting since the modules constitute a considerable share of the overall cost connected to the construction of PV plants. Other factors that help to decrease the total cost of PV Solar plants are reduced labour costs, improved experience among plant developers and sharing of best practise in addition to better supply chain structures (IRENA (A):, 2020, p. 64)

Despite the general trend of declining cost, the total cost of developing Solar PV plants still varies massively from market to market. For instance, In India in 2019 the total cost of utility scale Solar PV installations was 618 USD/kW while the cost in Russia in the same year was three times more at 2117 USD/kW (IRENA (A):, 2020, p. 66). Factors such as presence of NGO's, national incentives and subsidies can have an impact on the cost. In order to examine the different markets' attractiveness it is therefore important to understand the cost breakdown of building Solar PV plants. In the following, The main costs under the three main cost categories, hardware cost, installation cost and soft cost will be accounted for. The cost of selected markets is available in appendix 1.

5.1 Hardware cost

The hardware costs of PV plants consist of modules, inverters, racking and mounting, grid connection, cabling and wiring, overcurrent and surge protection equipment, grounding equipment, tilting systems, power storage systems, electricity meters, fuse boxes, charge controllers, AC isolators, DC isolators, transmission lines, safety and security and monitoring and control. Depending on the contractual relationship, the acquisition of land can also fall under this category (IRENA (A):, 2020, pp. 64–66).

A photovoltaic system (PV) is composed of a number of solar modules. Each module consists of a large number of solar cells where a small amount of electricity is generated in each cell. The size of PV systems vary from small rooftop installations to large power plants that can generate several hundred MW (Afework et al., 2020).

The process of converting light (photons) into electricity creates direct current electricity (DC). Within the electrical grid, power is transmitted primarily as alternating current (AC) and therefor power inverters are used to convert DC power into AC power. Despite being a relatively small component the inverters are therefore a key component in solar PV power generation (Afework et al., 2020).

While the prices on solar cells and PV modules have dropped significantly over the past decade, a consolidation within the PV module industry has also occurred. In 2019 the top 20 players within PV module manufacturing accounted for 71% of global shipments. This trend is likely to continue in the next year with especially China being the global leader within production of modules (Zoco, 2020). On a general note, there is low forward/backwards integration within the value chain. However, some companies have chosen to integrate horizontally and operate both as manufacturers of solar cells and modules while also acting as PV plant developers.

Figure 2 illustrates the different steps in the value chain and some of the major companies in each of the value chains levels.

5.2 Installation cost

The installation cost of building PV plants consists primarily of costs connected to mechanical installation, electrical installation, and inspection. Some of the main tasks include construction site management hereunder preparation of local infrastructure including access roads, fences, and security. Ground and foundation works comprise the preparation of soil and foundation works for the support structures. In large-scale plant construction, driven pile supports are the most common foundation method applied. Preparation of cable routing includes excavation of cable trenches and ducts besides installation of the cables. Other installation jobs include the installation of the racking system, solar modules and inverters, installation of grid connection components and transporting and uploading of components (DAO, 2017).

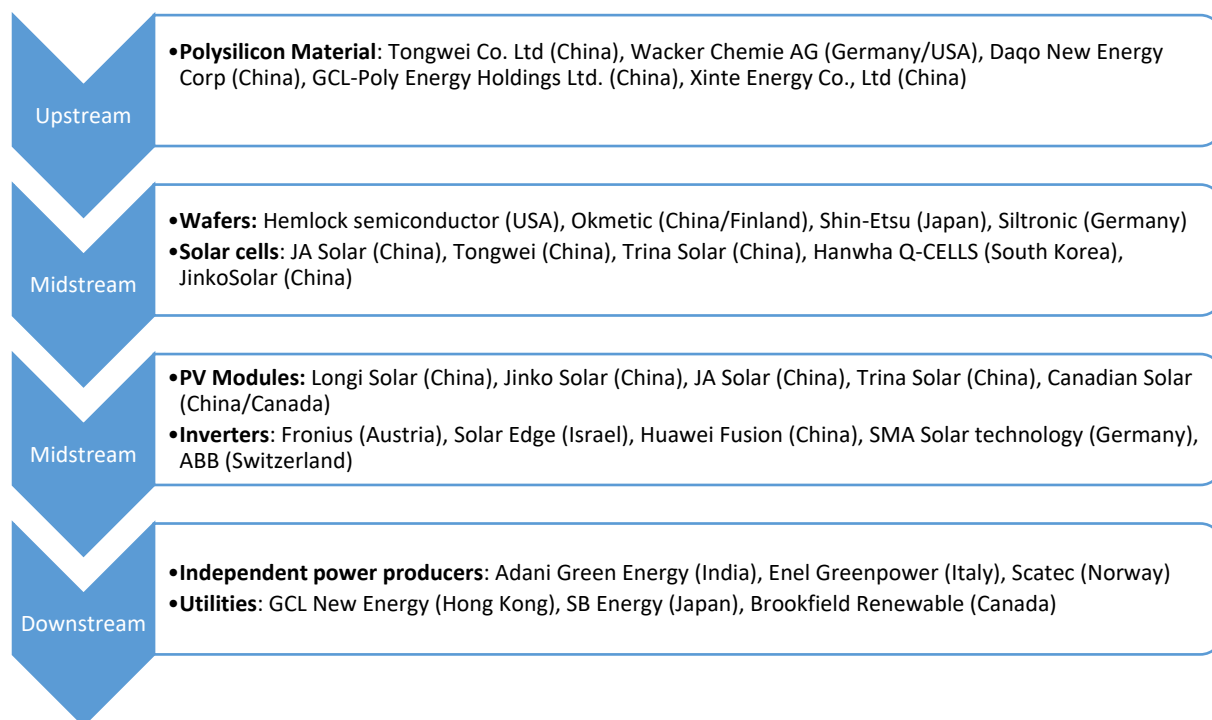


Figure 2: Value chain in the Solar PV industry (Author's own illustration)

5.3 Soft costs

In construction projects, soft costs refer to the costs that are not considered part of the direct construction hereunder materials, components, and installation (IRENA (A):, 2020, p. 66). The soft costs of solar PV projects' development include pre- and post-construction expenses, overhead and margin, financing cost, system design, permitting, incentive application and customer acquisition (IRENA (A):, 2020, p. 66).

The number of permits and licences needed to build and operate solar PV plants varies a lot from country to country. So does the administrative procedures and the level of transparency in the processes of receiving the permits from local authorities. Ultimately, the cost and time needed for this part of the project planning can vary substantially from market to market.

As an example, in Indonesia it used to require 14 different licenses and permissions to develop solar and wind projects - nine of those had to be required at local level. Complex procedures, unclear decision power and different notions among local authorities made this process challenging and burdensome for local developers, but even more challenging for foreign-based companies. These complex procedures have now been eased by the Indonesian government's establishment of a one-stop agency, Badan Koordinasi Penanaman Modal (BKPM), which

guides investors through the investment process, planning, application for approval, approval procedure and project implementation (Keeley & Matsumoto, 2018, p. 346). The challenges and cost connected to the administrative procedures including permitting will be covered under section 11 barriers to FDI and section 13 technical barriers and infrastructure.

6 Selection of variables

The selection of market variables and the weighting of those is based on existing literature and interview contributions. Keeley and Matsumoto's study from 2018 "*Relative significance of determinants of foreign direct investment in wind and solar energy in developing countries – AHP analysis*" compares the significance of different market variables within wind- and solar projects. Their study is based on 21 respondents from international solar- and wind companies. This study finds that the most important determinants of FDI in the solar- and wind market are exchange rate volatility, access to land, priority access to grid, natural resources, administrative procedure, feed-in tariff and access to local finance.

Interview participant number two shared his view on some of the most crucial variables to think about before the location choice is made. First, he explained that the most important aspects to consider is the solar resources. Apart from this, he emphasized the need to consider the development in the area in terms of electric infrastructure and grid connection, as some areas might have the infrastructure, but lacks the capacity in the power lines to take the energy (*Interview participant 2*).

Local environmental issues must also be considered as the location may seem reliable, but local regulation can be very restrictive and at the point of deployment, it might turn out to be impossible to erect the facility. Construction and procurement issues need to be assessed, hereunder the local infrastructure to allow trucks and materials to enter the construction site. As an example, it could be necessary to establish access roads to allow the materials to arrive at the point of construction (*Interview participant 2*).

Finally, interview participant number two mentioned access to local labour force as a determinant of attractiveness. Whether or not it is possible to attract the right personnel locally or if it will be necessary to source from other locations or even from abroad is important. Relationships with local regulators and utilities is another important aspect, as the construction

of the PV plant will require close collaboration with those stakeholders. Finally, the price of the electricity is another important aspect (*Interview participant 2*).

On the basis of these findings and the aspects mentioned by participant 2, six market variables have been chosen as market determinants for PV developers in LATAM. The variables are:

- Ad-valorem tariffs
- Energy matrix
- Foreign exchange rate risk
- Barriers to foreign direct investment
- Renewable energy policies
- Technical barriers to trade and grid connectivity

7 Ad valorem tariffs

The first variable that will be analysed is ad-valorem tariffs. Out of the six variables that will be analysed in this thesis, ad-valorem tariffs have been given the lowest weight, accounting for 9%.

Potential high ad-valorem tariffs affect the cost of building and ultimately also the levelized cost of electricity (LCoE) that consumers pay. As described earlier the supply chain of the Solar PV industry is a global one, but with a strong concentration within panel and module production in China. For companies that want to invest in one of the four markets chosen for the shortlist, the level of tariffs on key components like solar modules, cables, inverters, and racking might affect their investment decision and competitiveness.

High tariff levels in the target market can make it unprofitable to source from suppliers abroad, that the company might normally engage with on regular basis. In this case, companies will have to look for new suppliers either in the local market where tariffs do not apply or from other countries where tariff rates on imports are lower. This could provide an obstacle for foreign companies and lead them to the assessment that the market is not attractive.

Tariffs on components could also affect PV developers' ability to compete with substitutes like thermal plants or hydro and wind energy. If the tariffs on components lead to a substantial increase in LCoE on solar power, it might cause utilities and other clients to look for alternative energy sources.

On the other side, since all PV developers should be subject to the same level of tariffs on imports within each market, the tariff-rates should not be very critical to foreign companies' ability to compete with domestic companies within the local Solar PV industry. Therefore, a relatively low weight has been granted for this variable.

7.1 Analysis of ad valorem tariffs

For the purpose of comparing the levels of tariffs for each of the four countries, data from the World Bank has been used. The applied tariff level for imports of solar modules, inverters, aluminium structures and HV cabling exceeding 1000V have been compared for each of the four countries in figure 3.

Imports from China, Germany and USA were chosen as the measurable since China and the USA constitute some of the biggest manufacturing countries within the Solar PV industry. Germany was chosen as the third country due to their membership of the EU and the internal market, which means that the applicable tariff rate on imported products from Germany will in most cases, reflect tariff rates for imports from the remaining EU countries.

Component	HS code	HS Category	Import country	MFN Tariff	Applied tariff (China)	Applied tariff (Germany)	Applied tariff (USA)
Solar PV modules	854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light emitting diodes	Argentina	3.22	3.22	3.22	3.22
			Brazil	1.89	1.89	1.89	1.89
			Chile	6.00	0.0	0.00	0.00
			Mexico	0.00	0.00	0.00	0.00
Inverters	850440	Electrical static converters	Argentina	14.89	14.89	14.89	14.89
			Brazil	16.89	16.89	16.89	16.89
			Chile	6.00	0.00	0.00	0.00
			Mexico	2.19	2.19	0.00	0.00
Racking	761090	Aluminium; structures (excluding prefabricated buildings of heading no. 9406) and parts of structures, n.e.s. in heading no. 7610, plates, rods, profiles, tubes and the like imports	Argentina	16.00	16.00	16.00	16.00
			Brazil	16.00	16.00	16.00	16.00
			Chile	6.00	0.00	0.00	0.00
			Mexico	7.50	7.50	0.00	0.00
Cabeling transmission	854460	Insulated electric conductors; for a voltage exceeding 1000 volts	Argentina	16.00	16.00	16.00	16.00
			Brazil	16.00	16.00	16.00	16.00
			Chile	6.00	0.00	0.00	0.00
			Mexico	5.00	5.00	0.00	0.00

Figure 3: Tariff rates for selected components (Author's own illustration based on data from the WorldBank)

7.2 Assessment of variable

The results show very clearly that out of the four countries Chile has the most liberal regulation on tariffs with 0% for all of the four product groups. In the case of Mexico, the rate is 0% for all product groups imported from the USA and Germany, and for solar modules imported from China. HV cables, racking and inverters imported to Mexico from China is subject to moderate tariff rates ranging between 2-7,5% (*Worldbank (World Integrated Trade Solution)*, n.d.).

In the case of Argentina and Brazil the tariffs on inverters, aluminium racking and HV cables imported from China, Germany and the USA are high ranging between 14.89-16.89%. The tariff on imported solar modules in Brazil is 1.89% and 3.22% for Argentina. It is worth noticing that these two countries are also the biggest producers of aluminium in South America, which increases the likelihood of finding suitable local domestic suppliers (Rupankar, 2021).

The markets have received the following scores on this variable:

Ad valorem tariffs (weight: 9%)	
Chile	10
Mexico	8
Brazil	5
Argentina	4

8 Energy matrix

The second variable is the energy matrix. This variable covers from which energy sources each of the four countries gets their supply. This variable has been given a weight of 11% making it the fifth most important variable.

The output that Solar PV developers sell will in most cases be electricity, therefore they are very much competing with substitute generation methods. These other generation methods can be divided into two groups. Competing RE generation methods, hereunder onshore- and offshore wind, biomass and hydropower. In the other group conventional generation methods powered by fossil fuels like coal, oil and gas are found. For PV developers it is relevant to be aware of the energy matrix in the country to assess how much competition and resistance they are likely to meet from established energy industries.

8.1 Energy matrix in Argentina

In 2019, Argentina's energy generation was 132.206 GWh. Non-renewables constituted 68% while renewables constituted the remaining 32% with marine and hydropower as the largest renewable contributor, together constituting 26% of the total generation. The share for wind power was 4%, bioenergy 2%, solar power 1% and geothermal energy 0%. The power generation from solar power amounted to 801 GWh. In the non-renewable category, gas was the largest energy source accounting for over 54% of the total energy supply in 2018. The capacity change from 2019-2020 was highest within solar generation that went up 72% closely followed by wind that was up 63% (*IRENA: Energy Profile Argentina*, 2021, pp. 1–2).

Argentina has the fourth largest oil reserve in South America after Venezuela, Brazil and Colombia and the country is also the fourth largest oil producer on the continent with a production of 593,000 barrels of oil per day (BOPD). Argentina is the largest producer of gas in South America with a production of 37.1 billion cubic meters. According to the US Energy Information Administration assessments Argentina has the world's fourth largest potential of unproven but technically recoverable reserves of shale oil and the second largest reserve of shale gas globally (The energy year, n.d.)

As already mentioned, Argentina has very favourable natural conditions for Solar PV exploitation with more than two million km² in the excellent, outstanding, and superb solar radiation categories. The Solar PV industry is likely to experience strong competition from the wind energy industry as the country also has very favourable conditions for wind exploitation. 70% of Argentina's land area has annual average wind speeds of more than 6m/s and especially the area of central and southern Patagonia is interesting for land based wind-turbine developers as wind speeds here on average reach 9-12 m/s (GlobalData Energy, 2020).

8.2 Energy matrix in Chile

Chile's energy generation in 2019 amounted to 83,618 GWh. Non renewables constituted 55% of the generation with oil as the largest contributor accounting for 42% of the total generation in 2018. Coal is another major energy source making up 18% of the total energy supply in 2018. The numbers for the renewable energy sources in 2019 was 26% for hydro and marine power, 8% for solar power, 6% for wind power, 5% for bioenergy and 0% for geothermal

energy. The solar capacity totalled to 6419 GWh in 2019. The highest capacity development from 2019-2020 was found in the wind segment (+32%) and solar (+21%) (*IRENA: Energy Profile Chile, 2021*).

Chile has few fossil fuel resources, and therefore, they have been reliant on imports of coal, oil and gas. Some of the major exporters of coal to Chile are Colombia, USA and Australia while big exporters of oil are Brazil and Ecuador and in the gas segment Trinidad and Tobago (BN Americas, 2015).

The country has very favourable conditions for solar PV exploitation especially in the area of the Atacama Desert in the north. In the southern end of the country and the Magallanes region wind energy constitute a substantial potential with particularly strong winds. There are challenges connected to transmission of electricity in Chile due to the country's special geography. Both the sunny Atacama Desert and the windy Megallanes region are located far away from the industrial hub and capital of Santiago de Chile, located in the middle of the country. This means that electricity generated in these regions will have to travel long distances in power lines with energy losses. The Energy policy is primarily driven by the need to reduce the vulnerability towards global fluctuating commodity prices, as Chile is a net importer of fossil fuels like oil, gas and coal (Bertram, 2021)

8.3 Energy matrix in Mexico

Mexico had an energy generation of 331,264 GWh in 2019. Out of the four countries chosen for the shortlist, Mexico had the largest share of energy from non-renewable sources with 83%. Both oil and gas are major energy sources accounting for 46% and 36% of total energy supply respectively. Among the renewables, hydro- and marine power had the largest capacity with 7% compared to 5% for wind, 2% for solar, 2% for geothermal and 1% for bioenergy. The biggest capacity changes from 2019-2020 was found in solar (+27%) and wind (+23%) (*IRENA: Energy Profile Mexico, 2021*).

As covered earlier, Mexico has significant potential for solar power generation with high solar radiation across most of the country. There is also substantial potential for wind exploitation in southern states such as Oaxaca and Yucutan (Gabbatiss, 2021).

Mexico has a diversified energy mix. The country is rich in fossil fuels including both coal, oil and gas. In 2020 Mexico ranked 13 globally in crude oil production and the country is a big

exporter of oil to the USA. In 2020, Mexico exported 240 million barrels of crude oil to the USA. Oil is an important part of Mexico's economy, and in 2020 the oil industry accounted for 58% of total government revenues (International Trade Administration, 2021).

The Mexican oil and gas industry is dominated by the state-owned company Pemex which have been further strengthened by the Mexican government during 2021. Earlier in 2021, Pemex received 3.5 billion USD in financial support from the government to strengthen the company's finances. Besides that upgrading, six of the company's refineries also remain a key interest for the Mexican government and Pemex itself (International Trade Administration, 2021).

8.4 Energy supply mix in Brazil

Out of the four target markets, Brazil had by far the largest energy capacity with 626,339 GWh in 2019. Brazil stands out from the other three countries by being the only country that has a larger share of energy supply coming from renewables with 82%. Hydro and marine power are by far the largest sources of energy in Brazil with 64% of the total energy generation. Wind and bioenergy accounted for 9% each, while the share for solar energy was 1% and 0% for geothermal energy. Despite the low share of solar power in the energy matrix, this energy source still accounted for 6665 GWh due to the high total energy consumption in the country. The biggest capacity change was found in solar energy increasing by 71% from 2019-2020 followed by wind with a capacity change of 11% (*IRENA: Energy Profile Brazil, 2021, pp. 1–2*).

Brazil has the largest oil production in Latin America with an annual oil production of 1018 billion barrels of oil in 2019. The country owns the largest recoverable ultra-deep oil reserves in the world of which most are offshore. The state-owned company Petrobras is responsible for 92% of Brazil's oil and gas production (International Trade Administration (B), 2021). Most of Brazil's oil and gas production is exported and is therefore not used for domestic electricity generation.

Instead, hydropower plants have dominated the Brazilian power generation for many years. With large rivers and elevation changes, the country is ideal for hydropower production. The potential for future growth within hydropower is limited because of the already record high share of hydropower in the energy matrix. Another explanation is that more frequent and longer lasting droughts possess a risk to stable power production based on hydropower. This has

forced the country to look for other renewable energy sources of which wind- and bioenergy is the most dominant (GlobalData Energy (B), 2021).

The Brazilian wind sector has grown rapidly during the past decade and in 2021 Brazil's installed wind capacity reached 19 GW. According to a forecast presented by the Brazilian Wind Energy Association (2021) this number is expected to grow to 30.2 GW in 2024 (REVE, 2021). The potential for wind exploitation is particularly high in the coastal area in the north-eastern part of the country (Araújo et al., 2021, p. 17).

8.5 Assessment of variable:

When looking at the competition from other energy sources, Chile has been chosen as the more attractive market out of the four countries. Chile already has a relative high share of electricity coming from Solar PV relative to the other countries, which means that Solar PV construction is no longer an infant industry in the country. The fact that Chile is reliant on imports of oil and gas contributes to a long-term economic interest in the promotion of renewable energy sources. This is likely to secure high future demand for added capacity of solar PV energy with frequent tenders that PV developers can bid for.

According to the analysis, Mexico is at the other end of the scale as the least attractive market on this variable. The country has a huge oil and gas sector supported by the government. This sector weighs a lot in the Mexican economy both in terms of jobs and government revenue. The country's interest in the oil and gas sector could turn out to be an obstacle for further expansion of RE plants. Among the RE sources, wind energy has taken up a larger share of power generation compared to solar generation.

While Brazil has an impressively high supply of RE, it is dominated by hydropower. The prevalence of Solar PV generation is low even in comparison with wind energy. This trend is similar in Argentina. It is however worth to notice that solar power was the fastest growing energy form in both countries between 2019-2020.

The countries have received the following score on this variable:

Energy matrix (weight: 11%)	
Chile	8
Brazil	5
Argentina	5

9 Foreign exchange rate risk

The third variable is foreign exchange rate risk. This variable has been given the second highest weight of 21%. The primary reason for this is that PV developers typically enter long lasting contracts of up to 25 years. In the weighting of this variable attention has also been given to Keeley and Matsumoto's (2018, p.346) study "*Relative significance of determinants of foreign direct investment in wind and solar energy in developing countries – AHP analysis*" where exchange rate volatility was given the highest importance by participants.

There are numerous challenges related to foreign exchange rate risk for solar PV projects in developing countries where local currency is not pegged to the USD. This applies both to the financing of the construction of the plant and to the long-term cash flow when the electricity is sold through PPAs. In many cases the PPA agreements are done in local currency and if the local currency devalues, which it has a tendency to do in developing countries, so does the value of the PPA agreement for the developer.

One way to mitigate this risk can be to form agreements in foreign currencies like USD or EURO. This arrangement pushes foreign exchange rate risk in the direction of local utilities and consumers instead of the project developer. However, this solution is not sustainable on a long-term basis as it can result in very high electricity prices for local consumers as the local currency devalues. This can cause authorities to opt for fossil fuels instead, like oil that fluctuates with the crude-oil prices (Warren, 2017).

The exchange rate risk can be reduced by entering PPA agreements in local currency coupled with local currency financing. However, in many developing countries there might be a lack of liquidity and willingness to provide the funding. One solution to this can be partnership financing where development finance institutions like the world bank partner with local banks to provide a low interest rate and loan guarantees (Warren, 2017).

9.1 Exchange rate risk Argentina

The history of the Argentinian economy is a dramatic one. Since the independence from Spain in 1816 the country has both been through economic upturns especially in the beginning of the

20th century and through several economic crisis like the “Argentine Great depression” from 1998-2002. The government have defaulted payments no less than nine times during its independence, most recently in 2020 when the country failed to pay 500 million USD in interest on its bond debt (Garrison et al., 2020).

The latest economic forecast for 2021 from the Argentinian central bank suggests an economic growth of 7.2% in Argentina this year, which will mark an end to a three-year long recession (Reuters, 2021). However, the economic outlook for Argentina is still very blurry. The country currently has an inflation rate of 46.90% making it the 4th most inflationary economy in the world after Venezuela, Zimbabwe and Sudan (World Population Review, 2021).

As a consequence of the high inflation, which has dominated the economy since 2002, the central bank has raised the interest rate to 38% (Trading Economics, 2021). Argentina has a debt of 323 billion USD and the payment of the debt is not made easier by the depreciating Argentine Peso (Nik, 2021).

Argentina’s poor economic performance and the instability of the Argentine Peso has been a huge problem for local industry for decades as it discourages FDI due to the foreign exchange risk. This is also the case for renewable energy investments, which typically has long payback periods of up to 25 years. The Argentine Peso has depreciated extremely towards major world currencies like the Yen, USD and EURO during the past 20 years. The latest S&P credit rating of the Argentine economy was CCC+ with a stable outlook, indicating substantial risk in the creditworthiness (Trading Economics (B), 2020).



Figure 4: Argentine Peso to Euro chart (Exchangesrates247.com)

9.2 Exchange rate risk Chile

Chile is one of the best performing economies in Latin America. It became the first South American member of OECD in 2010. Apart from Chile, Mexico, Costa Rica and Colombia are the only other OECD members in Latin America although the council has very recently opened accession discussions with Brazil, Argentina and Peru (OECD, 2022).

From 2003 to 2013 real growth averaged nearly 5% per year. Since then growth has slowed down to approximately 1.4% per year partly due to lower copper prices, which is Chile's number one export and constitutes 20% of government revenues (CIA, 2021).

Chile has a market-oriented economy with a high level of foreign trade and strong financial institutions. The country has 26 trade agreements covering 60 countries including the EU, Mercosur, China, India, South Korea and Mexico. The government has followed a countercyclical fiscal policy based on accumulating surpluses in periods with high copper prices and economic growth and allow deficit spending in periods with low copper prices and low economic growth (CIA, 2021). During the past decade, the inflation rate has been kept at a low level ranging between 1 and 4%.

The Chilean Peso has been a free-floating currency since the beginning of this century, though the central bank has intervened a couple of times during the past decades to control volatility. The latest credit rating from Standard and Poors from March 2021 rated Chile with an A rating and a stable outlook (Trading Economics (C), 2021)



Figure 5: Chilean Peso to Euro chart (Exchangerates247.com)

9.3 Exchange rate risk Mexico

Mexico's economy has grown to become one of the 15 largest economies in the world. Especially the manufacturing industry account for a large share of Mexico's FDI and exports. Mexico has free-trade agreements with 46 countries of which the USA by far is the most important export market. The high share of trade between the USA and Mexico makes the economy vulnerable towards domestic political shifts (CIA (B), 2021).

From 2009-2018 Mexico's economy grew 2-3% annually while there has been negative growth in 2019 and 2020. Especially the pandemic year 2020 struck the economy hard with a GDP fall of 8.2%.

The Mexican peso has depreciated towards the Euro and the USD during the past decades. Like other major oil producing countries, Mexico's currency correlates with oil prices as international lenders are more likely to invest when crude oil prices are high (Currency converter, 2021).

Apart from having a higher inflation rate compared to the USA, Mexico also has a higher interest rate currently around 5%. The Mexican Peso is one of the top 15 most traded currencies in the world and have evolved from a local currency to an internationally accepted currency (Farley, 2020). The S&P credit rating for the Mexican economy from March 2020 is BBB with a negative outlook (Trading Economics (D), 2021).



Figure 6: Mexican Peso to Euro chart (Exchangerates247.com)

9.4 Exchange rate risk in Brazil

Brazil is the largest economy in Latin America and the eight largest economy globally. In the beginning of the 2010s Brazil experienced rapid economic growth, but in 2015 and 2016 the economy took a downturn and the country went into recession. The economy was further harmed by multiple corruption scandals involving some of Brazil's largest companies and government officials (CIA (C), 2021).

After a couple of years with very modest economic growth, things turned worse in 2020 when the COVID-19 pandemic hit the country. Brazil has suffered from more than 590,000 deaths due to the pandemic making it number two globally in terms of total number of deaths (The World Bank, 2021). The economy has also been negatively impacted by the pandemic and last year the GDP fell 4.1%. Like many other countries, the economy has bounced back in 2021 supported by one of the largest stimulus packages in emerging markets of nearly 4% of GDP (IMF Country Focus, 2021).

During the past decade the Brazilian Real has depreciated towards the EURO, USD and other major currencies and especially during 2021 the inflation rate has surged to approximately 10%. The Central bank has increased the interest rate (Trading Economics (E), 2021). The credit rating from S&P grades Brazil BB- with a stable outlook (Trading Economics (F), 2021)



Figure 7: Brazilian Real to Euro chart (Exchangerates247.com)

9.5 Assessment of variable:

In terms of exchange rate risk, Chile has been chosen as the most favourable market. The Chilean economy has grown steadily during the past decade and even though the Chilean Peso

has a tendency to depreciate towards major currencies the overall assessment is that the country has a strong capacity to meet financial commitments which is reflected in the latest credit ratings of the country. The market-oriented economy contributes to enhancing the ease of doing business for foreign companies.

In the other end, Argentina appears – according to the analysis, to be the least attractive country on this variable. In terms of economic performance, history seems to repeat itself in Argentina. The extremely high inflation and fiscal deficit creates uncertainties for foreign investors which is reflected in the credit rating that grants Argentina a speculative grade, suggesting that the economy is vulnerable and dependent on favourable business, financial and economic conditions in order to meet financial commitments.

Mexico and Brazil are found in the middle. Both countries have very large economies, but do also have a history of fluctuating currencies related to country specific challenges.

The countries have received the following score on this variable:

Exchange rate risk (weight: 21%)	
Chile	6
Mexico	5
Brazil	4
Argentina	1

10 Barriers to FDI

The purpose of this variable is to cover potential barriers to FDI, which cannot be classified as economic barriers to trade, such as tariffs, nor technical barriers to trade such as grid connectivity, which will be covered later. This section seeks to cover some of the main trends in the business environment that companies need to pay attention to in each specific market. The variable has been given the highest importance of the six variables with a weight of 22%. While it is less quantifiable compared to tariffs for instance and therefore more difficult to measure, these barriers can also prove more difficult for foreign companies to foresee, prepare for and overcome. In this section, much attention has been given to some of the statements that was given during the interviews. This choice is based on the difficulty of direct quantitative measurements, while also being motivated by the depth that the interview data brings.

10.1 Barriers to FDI – Brazil

There are plenty of barriers to trade in Brazil and the country is regarded as “mostly unfree” in terms of economic freedom. Some of the most common barriers to entry in Brazil include extremely protectionist policies, inadequate infrastructure, unyielding labour laws and very complex tax and regulatory requirements. Another very common challenge to establishing successful business activities in Brazil is the widespread occurrence of corruption (Warburton, n.d.).

These traits of the Brazilian business environment is also prevalent in the solar PV industry. One interview participant replied that his company had won contracts in the Brazilian solar PV market, but that they are no longer engaged in solar projects in Brazil. The reason for their exit was the nature of the challenges they encountered during the first projects. One main issue they encountered was that local companies was favoured by the utilities. Regarding the tender phase of one project, interview participant 1 explains:

“We were doing offers in the electronic platforms - very formal and sometimes we realised that it was OK - this is balanced, but it was a kind of a mask. They have special public tenders, the public company utilities that is owned by the government. At some point we all realized that... You have a parallel. You have the people that are looking on the platform from the public utility and they are more or less connected with someone. Most part of them, Brazilians. And then, uh, if what we understood” (Participant 1).

The company did also have trouble during the execution phase, where they felt that the local utility opposed their work. Interview participant 1 explains:

“We won a bid for one MW project that was one of the first projects of solar in Brazil. We followed all the rules, but in the first meeting we realised that the people of this utility was more or less upset of Efacec winning the bid. We had terrible headaches. One of the first questions was how much money we had for penalties. The first meeting on the project and the guy asked you how much money you have for penalties.” (Participant 1).

The interviewee did also mention other structural barriers to trade in Brazil such as local tariffs and discriminatory practises towards foreign vendors. As an example, he explained that in some projects they had to pay taxes of storage of components in some states and again that they had to pay taxes for the movement of components from state to state at the point where the

components had to be transported from warehouses in port cities to the installation point. According to the interviewee, these problems were not applicable to the Brazilian contractors.

Another issue highlighted by participant 1 was the fiscal policies. There were challenges during the project execution were the company had to have a fiscal expert attached to the project, but also at the end of the projects when the company would allocate profit to the Portuguese mother company:

”I cannot bring the money back to Portugal. Because it is another difficulty. It is very difficult to make the preparation, for example to receive dividends is almost impossible. And so talking about Brazil? Uh, I don't recommend Brazil to anyone” (Participant 1).

Interview participant 2 did also have experience with PV projects in Brazil and the company is represented with a local project team in Sao Paulo. In general, they had fine relations there, but the participant confirmed that local content requirements and tariffs attached to both services and components is an obstacle. About the tariffs on services he explains:

“The main concern of Brazil is the local regulation for the local content. In Brazil, for example, if you want local content it means that... My company Worley, we have a specific office in Sao Paulo and we work with our colleagues. If they are doing a PV, a big plant - right now they're deeply involved in several projects and they need support from our office in Madrid. When they want to pay the service from our office, they need to increase 30% because the local they consider our service as an importation. Yeah, and you need to pay... If you want to buy or sell any PV models there, there is still services or whatever, and this percentage is 30%. So, even though it's not a component you buy, but in this case a service and some consultancy, there is a tariff. (Interview participant 2).

The Interview person did also confirm that tariffs were applicable to many components needed for the projects:

“Yeah, even if you don't have the component in the country you need to pay. Well, if you don't have the component in the country. You will pay different fee but you will pay”

Interview participant 3 had mainly been involved with PV projects in Brazil and Honduras. In general, he had a positive outlook on the Brazilian solar market. He did however confirm that high levels of bureaucracy and corruption are prevalent:

“In general, you know Latin America, it's a region where corruption levels are high and bribery and everything regarding bureaucracy. You know that we have in Brazil. There's a lot of bureaucracy. There are a lot of regulations and a lot of permits. I cannot even name them all - every time I discovered something new. Even not in my area, which is HSSE. But the way that we do business... You know we have a compliance department and we have a code of conduct that dictates anti-corruption guidelines, transparency and how we do business, as you know. So how we need to act with customers and with government agencies. I cannot tell you that we have had any type of incident because that's not my area. But I know that we have a compliance and due diligence. We are also doing an ID integrity due diligence before we invest in a project. Having this ID to suppliers to contractors or to certain companies or joint ventures is a way for us to check and screen our potential partners or our customers. In this case the energy company. To verify that they are complying with the laws and with business integrity as well. I haven't had any experiences, but I know that we do have a pretty strict anti-corruption guidelines that you can actually check on our website.” (Interview participant 3)

10.2 Barriers to FDI Chile:

Chile ranks 59 globally when it comes to ease of doing business. The Country is relatively even within all of the topics that the World Bank measures and can be found in the top 100 on all of them. Subjects where Chile does particularly well are; getting electricity, dealing with construction permits and protecting minority investors (The World Bank (B), 2022).

Interview participant 1 was generally very positive about the Chilean solar PV market and described it as a relatively easy market to operate in. He explained:

“We are very successful in Chile. Portuguese companies and of course Efacec. In Chile we build solar PV plants. Currently we are not building anyone because of the COVID situation and the problems in the PV modules industry, but we were very successful. We profited a lot in the projects and we are not just another... At least 3-4 other companies of Portugal are involved in the solar and in wind. It is very easy to understand the way of doing business. The tax system is very easy... And of course they have lots of resources. Solar radiation in the north is one of the highest in the world. In the South, lots of wind. Uh, resources... It is very easy... For example, if you want to import anything you do not pay customs. They don't have duties like Brazil for example. And it's very easy, for

example, because it's a country of mines. If you remember, they have sometimes... They had big accidents in their mines. They are very strict on the health, security and quality... And they have penalties to pay. It is that simple. If you follow the rules - it is easy." (Interview participant 1).

Interview person 1 did however mention that it was difficult to find skilled local labour with the right qualifications. This applied both to skilled workers and engineers in their Chilean projects. Interview person 2 had also encountered challenges related to finding local labour force for Chilean projects. About one project he explains:

The area in which all these deployments are right now... Where they are under development or construction is an area without people so they have base camps for the workers. They moved from the South, because in this area there is practically not any life. It's an area in which there is only... It's a big desert. Yeah, it's practically impossible to live there because it's pretty dry. Well, there is only a small town in Santo Farestere and it's quite difficult to get labour force to erect these facilities. We did a project for EDF - for electricity France. Yeah, this project had almost 200 MWP. It was pretty expensive because they spend a lot of money on base camps and they had a lot of workers practically one year and a half, and you need to pay for that. You need to build the facilities you need to get some kind of location for fun because there is nothing there, so they erect one bar, one movie room, because it was particularly impossible to live there nice.

To get labour force they were trying to get people from the local mining, but the local mining guys are earning a lot of money. Compared with the money that they earn in the erection of the facility, so for them it was expensive to erect the facility there, similar to the location in which we erect the facility in Argentina. In Brazil it is different because Brazil it's a country with a lot of people and they have... It is possible, at least in the location in which we are working right now - it is possible to get local labour for this and with the expertise to do the job. The main technical heads are important. Yeah, you need to move the leaders from technical offices in Sao Paulo, Rio Janeiro or Chile Santiago to the location because it is impossible to get local labour with expertise in PV or wind.

Yeah, in Chile it was complicated. In Chile they had to import practically all the labour force to erect the facility. Practically, I would say that more than 90% of the labour force

was imported from other countries or from other regions in Chile. Yeah, and also from other countries, even from Spain. They bring people from Santiago Chile and they bring people from Peru. (Interview Participant 2)

10.3 Barriers to FDI Argentina:

The World Bank has ranked Argentina 119 out of 190 countries for ease of doing business. Some of the most challenging elements of the Argentine business environment has already been covered under foreign exchange rate risk and tariffs. Apart from those factors, some of the topics that makes business operation in Argentina difficult is paying taxes and dealing with construction permits where the country ranks respectively 170 and 155 on the world bank's business regulation index (The World Bank (C), 2021).

The amount of procedures and time consumption connected to dealing with taxes in Argentina is on a decent level and way lower than the average of Latin America. However, the tax rate in Argentina is extremely high both for individual income and for corporate tax income.

Concerning the construction permits the biggest challenge is the procedures and time that companies face when building in Argentina, while the cost connected to this process is fairly low. For instance, the estimated number of days that a company should expect for the consideration of necessary construction applications for building a warehouse is 318 days (The World Bank (C), 2021). Regarding solar PV development in Argentina interview participant 1 highlighted the economic circumstances as an obstacle to foreign companies. He explains:

“Argentina is a country where we had facilities since 1992. We have a factory in Argentina, but the problem of Argentina is nobody trusts in Argentina for investments. They have lots of projects, but nobody trusts because of the political instability. They are... They don't have enough money. I already went about 10 times to Argentina. Because my colleagues there they are the kind of people that look... This is my country - I want to make projects of solar. We have lots of resource. The energy is very expensive, but finally we don't. The local companies don't have money and foreigners they don't trust enough to build projects in Argentina, with the exception of few ones like Total. (Interview participant 1)

Regarding the ease of doing business in Argentina interview person 1 was generally positive. Despite many rules connected to imports and labour force he found the rules relatively easy to navigate and explains:

Yes, for example they have customs and duties, but it's very easy to understand. Uh, you pay 20%. Or in some cases, you are exempted like PV modules because they don't have local production of PV modules. The logistics are very easy to understand. They are very expensive. Uh, local subcontractors - you have to work with the ones that are connected with the local unions. If you do not contract any company... For example, if you bring people from abroad, like Bulgarians or from Spain or somewhere, you will have a problem because... The unions will be on the door of your project complaining, but from the beginning everyone tells you.” (Interview participant 1)

Interview participant 2 had also participated in several PV and CSP projects in Argentina. As it was the case in Chile they had experienced difficulties connected to hiring local labour:

Argentina is a country where they have in the capital... A lot of people - smart people, a lot of expertise. They are high developed in the engineering. However, we did the project in Los Angeles, in the north part of Argentina - very poor area. It was really hard to erect the facility there and we send people from our office here. There is a lack of expertise. In PV they are a little bit better but in CSP they are far away from the area. (Interview participant 2)

10.4 Barriers to trade Mexico:

In terms of ease of doing business, Mexico ranks 60 out of 190 countries. The topics where Mexico receives the highest score are; getting credit, resolving insolvency and enforcing contracts. Some of the most challenging topics include: paying taxes, starting a business and getting electricity (The World Bank (D), 2020). In the industry of solar PV generation, the latter does also constitute a business opportunity since the challenges connected to electricity supply for businesses could increase the demand for business to business PPAs.

Interview participant 1 had not participated in solar PV developments in Mexico, but the company was present in Mexico through other projects. He also explained that they were considering solar PV opportunities in Mexico:

“We are in environmental business and in hydro business as well. We plan to have a project of doing a rehabilitation of a dam next year in Mexico. In solar we tried but it is a market controlled by Spanish companies - normally Spanish companies. They only work with Spanish contractors. My opinion of the country is that it is a difficult country. They have few players. They have a very high level of bureaucracy. We are waiting for some of the Spanish... The Spanish are pulling out because they have lost some money there... But we are waiting for some opportunity to go there because I suppose they have a good resource. The major problem of Mexico is the security... For example if you go outside of... In the places, that you will build solar PV plants in. In the countryside, you can have very major security problems and nobody wants to work in this unsafe location... (Interview participant 1)

Interview participant 2 had not participated in major projects in Mexico. However, he did express that there are major issues connected to obtaining permits and that corruption is widespread. He explains:

“Mexico is another point – you have corruption. It’s really crazy... I have been talking with my colleague and she told me it is a nightmare to get the permission in Mexico. We are an Australian company with a specific value and we cannot give any money to get permission or whatever. If this is the requirement, we reject the project. However, she was working at another company and this company had other applies in this regard. And they were paying to get the permits. Yeah they were paying to get the permits in Mexico. The point is that local guys were asking money. Listen, now you want the permission? OK, no no the form is wrong. They were looking at a specific issue to delay the permits and to get money from the developer. This is Mexico” (Participant 2).

10.5 Assessment of variable

Chile has been evaluated as the most attractive market on this variable with a score of 8. The country has no major obstacles to foreign direct investment and the ease of doing business is high. Mexico has been given the second highest score with 6 followed by Argentina with 5 and Brazil with 4.

Barriers to FDI (weight: 22%)	
Chile	8
Mexico	6
Argentina	5

11 Renewable energy policies

This variable covers the respective governments' renewable energy policies and how energy supply is contracted. High importance of 20% has been given to this variable since the RE policies crafted now and during the past few years shape PV developers' business opportunities and relevance in each market. It is a very wide topic and therefore attention has been given to RE targets and specific mechanisms that promotes or oppose RE generation.

11.1 Renewable energy policy – Argentina

In 2017 Argentina's government declared a target to produce 20% of the country's electricity from non-conventional renewable energy sources by 2025 not counting hydropower as part of the nonconventional RE sources (Bauza, 2017). In the wake of that, the RenovAr program was developed with the purpose of attracting foreign investments and reducing RE prices. The framework includes long term bankable PPA agreements, incentives for fast project completion, measures to allocate grid interconnection capacity, federal tax incentives and loan guarantees to reduce investment risk (Marcacci, 2019).

The Argentine electricity system was privatized in 1992 with a reform that was created with the aim of promoting competition between private companies. This meant that the energy mix started changing from 1992. Until then, natural gas-fired thermal plants had been the dominant electricity generation source (Ruggeri & Garrido, 2021, pp. 2–3).

In the years following the Argentine economic crisis in 2001, imports of energy fuels increased in Argentina in order to supply a growing demand. The need to import energy fuels became critical to the Argentine government in 2011, as the imports generated a substantial mismatch in the balance of payments. Some of the measures taken by the government was investments in the electric infrastructure including the construction of 5500km of HV power lines and the creation of a public company named ENARSA (Energia Argentina SA). ENARSA was formed with the purpose of participating in the expansion of the domestic installed capacity. The demand for more energy capacity also led to the creation of the first renewable energy objective with the goal of achieving 8% RE supply within 2016 (Ruggeri & Garrido, 2021, p. 3).

Following this policy objective, the Genren program was launched in 2009 with the purpose to secure RE participation within electricity generation. As part of the program an ambition to generate 1015 MW of RE was presented. ENARSA was the company that would be responsible for the tenders, which were based on 15 years power purchase contracts in fixed dollar-pricing schemes. The tenders were backed up by mechanisms to encourage private investment despite the uncertainty of the Argentine economy. For instance, guarantees in cases of non-compliance were granted by Banco de Inversion y Comercio Exterior (BICE) a public bank with funds from the national treasury. However, the tender requirements did also contain local content requirements such as the requirement that projects had to have a national component and foreign companies were required to be associated with a local company. In the end the RE tenders part of Genren was not very successful - 895 MW was awarded following the bids, but only 193 MW were finally build and commissioned (Ruggeri & Garrido, 2021, p. 3).

Under the Mauricio Macri government (2015-2019) the orientation of economic and energy policy changed. The government aimed to re-establish market scheme and eliminate subsidies and government intervention. In 2016, the Renovar program was launched. Like Genren, the Renovar program comprised tenders for energy supply contracts but the program differed from the predecessor on several aspects. First Enarsas participation was cancelled and instead the tender and purchase role were handed over to Cammesa (the dispatch operator). The contracts were extended to 20-year power purchase contracts but remained fixed in dollars. For the financial support, guarantees from the world bank of 730 million dollars were added and unlike the Renovar program local companies were no longer required. The bidding resulted in a total award of 5560MW and the prices showed a considerable drop compared to the Genren program. According to Cammesa's numbers 3393MW were operating at the end of 2020 (Ruggeri & Garrido, 2021, pp. 4–5).

In September 2021 Argentina's government, send a bill to the congress to promote hydrocarbon investment. In this context president Alberto Fernandes stated: "*The ambition is for Argentina to produce in excess and export the surplus to bring in dollars*" and added "*We have to give the maximum boost to oil and gas activity*" For that we have decided to give certainty so that no one goes forward blindly seeing how things change in the coming months or years. It is a plan that foresees 20 years of stability in fiscal matters" (Bianchi, 2021).

This shows that despite the comprehensive work within renewable energy programs, the government is not yet ready to abandon conventional energy resources and therefore PV developers should expect continued competition from this segment in the next decades.

11.2 Renewable energy policy - Chile

The first RE target was adopted in 2008 and aimed to generate 10% of electricity from non-conventional renewable energy in 2024. In 2013, this number was raised to 20% by 2025. The National Energy policy 2050 targets 60% RE in 2035 (counting large hydropower as a RE source). Finally, the target to be achieved within 2050 is 70% RE electricity generation (IEA, 2018, p. 12).

In the past years, Chile has set up a number of institutions to support a long-term energy policy with a time horizon lasting until 2050. These new institutions include the Ministry of Energy, the Chilean Energy Efficiency Agency and the National Electricity Co-ordinator. During the development of the National Energy Policy 2050 the Chilean public was consulted on a broad basis. The result has been an energy strategy that was launched in 2015 and which are based on four energy policy pillars: 1) The quality and security of supply. 2) Energy as a driving force for development. 3) Environmentally-friendly energy. 4) Energy efficiency and energy education. (IEA, 2018, pp. 11–12).

Chile has strengthened the role of the state in energy planning and expansion to encourage investment in new capacity. The country used to have two major electrical systems – The Central Interconnected System (SIC) and the Greater Northern Interconnected System (SING). In November 2017 the two systems were interconnected and the National Electricity System was created (IEA, 2018, pp. 12–13).

Some of the policies and measures part of this strategy include Renewable-energy quota obligation on electricity suppliers, facilitating grid access for renewable-energy plants, facilitating the financing of renewable-energy projects, and raising awareness.

The RE quota obligation means that electricity generators with more than 200MW of capacity must account for the specific amount of electricity that comes from NCRE. The percentage should increase until 20% is reached in 2025. The legislation has penalties for generators that does not meet the quota. The legislation also allows “forced” auctions specifically for RE if electricity generators make insufficient progress towards meeting the renewable energy targets.

The Ministry of Energy monitors compliance with the targets. However, “forced” RE auctions have not been needed, as solar and wind projects have turned out to be very competitive in technology-neutral auctions for long-term PPA agreements. The RE quotas set by law have been exceeded by electricity generators year after year with as much as 300% in 2016. (IEA, 2018, pp. 147–148).

In order to secure allocation of public land to RE projects the Ministry of Energy collaborates with the ministry of National Assets to create procedures and allow the use of public land for renewable energy investments. In 2017 the maximum term for use of land for RE projects was extended from 30 to 35 years and the timeframe for construction of power plants was extended from 5 to 10 years (IEA, 2018, pp. 150–151).

Chile has some financing mechanisms for RE projects. The National Economic Development Agency (CORFO) offers a credit line for environmentally friendly technologies that can contribute with up to 40% of equity. Since 2016, the Ministry of Energy website have had a search engine for funding with access to 40 public financing instruments.

11.3 Renewable energy policy – Brazil

The Brazilian government has set a renewable energy target of 45% by 2030 as part of their energy plan towards 2050 (Molina Sánchez, 2020).

Between 1995-2002 the Cordosa administration privatized large part of the Brazilian electricity market and created the regulatory agency for the electricity market; Agência Nacional de Energia Elétrica (ANEEL). However in 2002 when drought hit Brazil and exposed the challenges to a hydropower based electricity system the market-based approach was criticized of not attracting sufficient amount of generation capacity (Fraundorfer & Rabitz, 2020, p. 654)

In 2004, the federal government reformed the Brazilian Energy system with the purpose to guarantee the security of energy supply, resource adequacy in investments and fair cost-reflective tariffs. Energy auctions was introduced as the primary tool to support those policy objectives (Tolmasquim et al., 2021, p. 3). The auction system is still in place today and apart from smaller adjustments in contractual clauses and bidding mechanisms the auction system follow the same rules and structures that was introduced in 2004 (Tolmasquim et al., 2021, p. 15).

The auction process in Brazil is led by ANEEL and follows three stages. First, registration and technical qualification of bidders. That stage is followed by the submission of bids and winner selection, and finally, a legal and financial qualification of the winning company is performed by a regulatory agency (Tolmasquim et al., 2021, p. 5). Technology specific auctions for renewable energy have been part of the program since 2007.

The auction program has turned out successfully in terms of the initial political objectives hereunder attracting private investment in new capacity. Since the beginning of the program 105 GW from greenfield power plants has been contracted through the auction system which is a capacity increase of 118%.

The fact that the electricity tenders in the auction system is based on 5-year demand forecasts conducted by distribution companies has been criticised as fluctuation in volumes and cancellation of scheduled auctions happens frequently (Fraundorfer & Rabitz, 2020, pp. 654–655). For developers of PV plants this can cause unpredictability and increased risk.

Access to preferential credit lines from the Brazilian National Development Bank (BNDES) for wind and solar power projects is tied to local content requirements.

The local content requirements are a challenge for PV developers due to an inadequate domestic manufacturing industry for PV modules in Brazil. Previously, this challenge also applied to wind developers that experienced difficulties sourcing wind power equipment in Brazil. However, the setup of local production plants by Siemens and Vestas have improved the access to those components in the Brazilian wind market.

11.4 Renewable energy policy – Mexico

Mexico has a clean energy generation target of 35% to be reached in 2024 and the country has also had shorter-term targets of 25% to be reached in 2018 and 30% in 2021. However, the Mexican targets are not binding, and the law has been criticized for lacks of mechanisms for accountability and enforcement. According to some analysts, Mexico reached their 2018 reduction target two years late in 2020 (Gabbatiss, 2021).

Under the former government of President Enrique Peña Nieto, Mexico introduced an energy reform in 2013. The Energy reform aimed to modernise the economy and secure long-term growth through increased efficiency and productivity. Historically the Mexican government had relied on the state-owned companies PEMEX and CFE to supply the country with

electricity from fossil fuel sources. However, with the new reform the state monopoly on oil and gas production ended. Bidding rounds in the oil and gas sector began in 2015 (IEA, 2017, pp. 9–11)

As part of the reform “The special program for the use of renewable energy” (PEAER) was published. The program was based on five objectives: 1) To enhance power capacity and generation from RE. 2) To increase public and private investment in power generation and construction/reinforcement of interconnection infrastructure. 3) To increase the use of biofuels in the domestic energy matrix. 4) To boost technology development, capacity development and renewable energy value chains. 5) To grant access to renewable energies for rural electrification projects, social participation and renewable energy use for thermal applications. (IEA, 2017, p. 170).

However, since the present government took office in 2018 the energy policy and strategy of Mexico have changed significantly. Already in 2018, President Andres Manuel Lopez Obrador promised to return the state-owned companies PEMEX and CFE to former glory. This objective has been followed by a series of political measures that disfavour foreign investment within fossil fuels and RE as well. First, the government suspended offshore exploration licenses until 2022, which means that foreign oil and gas companies cannot participate in the exploration of new oil and gas fields. Following that, Mexico’s fourth clean energy auction was suspended for unknown time. The explanation following this was that it will ‘likely’ take place when conditions are ‘optimal’. Then the Mexican Energy ministry changed the clean energy Certificate scheme to favour CFE rather than giving incentives and funding for RE projects. In May 2020, CFE passed a directive that limits renewable energy generation in Mexico. The explanation for this was that energy from RE sources destabilized the electric grid as COVID-19 affected energy demand. This meant that RE generation projects set to operate after May 3 2020 could not obtain an operation license (Farmer, 2020).

Most recently in September 2021, the Mexican government presented a constitutional reform of the electricity sector. This reform aims to reverse key parts of the 2014 reform. Especially the market opening towards private and foreign investment that was part of the 2014 reform will be limited if the reform passes. A key element of the reform is to secure that CFE maintain 54% of the electricity market which will leave 46% to private generators. At the same time, the reform will allow CFE to set the terms for private generators. Some of the other implications of the reform is cancellation of electricity generation permits, PPA agreements, self-supply

contracts and clean energy certificates for private and public electricity generators. The reform also seeks to abandon independent energy agencies (Breier et al., 2021).

11.5 Assessment of variable

In the assessment of the variable of renewable energy policies attention has been given to existing government targets for RE generation and the efficiency of existing policy mechanisms within the energy sector.

Once again, Chile has been evaluated as the market with the most favourable conditions for Solar PV developers. Along with other mechanisms, the quota obligation for RE generation has proved very successful in terms of increasing the share of RE generation. For Solar PV developers it is estimated to secure a stable long-term pipeline of potential Solar PV projects across Chile for the next decades. Argentina has also been granted a relatively high score as there are clear ambitions to increase the share of RE generation, especially the RENOVAR program has proved to be more successful compared to previous RE programs. The fact that the program is backed by funding from the World Bank strengthens the outlook for PV developers in the near future. From a longer-term perspective one could argue that it is worrying that the RE program is in need of external funding as future tender rounds might not receive financial security from the World Bank.

In Brazil the electricity auction program that applies to both renewable and conventional energy forms have been prevalent for more than a decade. The processes revolving the electricity auctions follow the same principle and is governed by the same institutions, which can be an advantage for foreign companies that wish to establish themselves within the Brazilian solar PV market. The prevalence of local content requirement and the high number of cancelled auctions draws the score down.

Mexico has received the lowest score. This is partly due to the current government's low ambitions within renewable energy generation and a low privatization within electricity generation that will reduce the supply of tenders that foreign companies can participate in. The country's strong interests within the coal and oil sector contribute negatively as well. However, it is important to mention that this could change again as previous administrations have been more favourable towards RE.

The countries have received the following score on this variable:

Renewable energy policies (weight: 20%)	
Chile	9
Brazil	5
Argentina	5
Mexico	2

12 Grid connectivity and technical barriers

One main challenge of building solar PV plants is the connectivity to the electrical grid and the condition of the electric infrastructure. These factors are crucial to whether or not solar generated electricity can be distributed to off-takers. This variable has been given a weight of 17%.

Usually when companies participate in public tenders, the government ensures that the facility can be connected to the grid. In those cases, the grid operator assigns a high voltage (HV) bay in a substation where the cables are connected. The retrofit and preparation of the HV bay can either be done by the PV developer or it can be prepared by the grid-operator depending on the specific contract requirements. In other cases when it is not a public tender the PV developer will have to negotiate how the plant is connected to the network with the local utility company (Interview participant 2).

Apart from the physical connection to the grid, PV developers also need to comply with the local RE Grid code. The grid code is specific to each country and contains the technical requirements that the facility should meet in order to get permission to inject electricity into the network. Some of the requirements are frequency response, reactive power behaviour, harmonic distortion, flicker, short circuit behaviour and low flow. It is mandatory to prove that the PV plant remains connected when there is a frequency dip(?). PV developers need to prove to local utilities that their plant will comply with the local electrical grid code. This matter should be considered already during the design phase in order to secure compliance at the point of connection. Usually this is done by simulating the behaviour of the network with special software (Interview participant 2).

Another aspect that is important to consider is the ‘quality’ of the electricity in relation to the network. Electricity from Solar PV plants is produced from static generators in contrast to synchronous generators. This electricity creates more harmonics also known as ‘noise’ in the

network. In relation to this Solar PV developers also need to prove that their facility is not affecting the quality of the network at the point of interconnection (interview participant 2).

This means that before entering a foreign market, PV developers must be aware of the permits needed for that specific market. This is because the level of documentation that has to be submitted and the transparency and cost of the application processes vary greatly. The structure and operation reliability of the electric grid can also limit demand for solar PV generation.

12.1 Infrastructure in Chile:

While Chile's geography brings a great potential for the exploitation of different RE generation methods, the country's geography does also create infrastructure-related challenges. The country is 4270km long but only 356km on its widest point (Nations Encyclopedia, 2022). The most favourable area for solar PV exploitation is located in the Atacama desert in the North of the country. This area is sparsely populated and located more than 1600km from the capital of Santiago de Chile and the main suburban areas of the country. This means that the electricity generated in the North have to travel far distances in order to reach consumers and industries, which puts demand on the composition of the electric grid. In recent years investments in the electrical grid have improved the possibilities to distribute electricity and exploit RE sources.

“Chile is probably the country with the best regulation in electricity. They have done the interconnection between the central network with the north network. They had a grid code for the north and a grid code for the centre and now they only have one code because they did the interconnection between both systems” (Participant 2).

Chile used to have two networks with individual grid codes, but since the interconnection of the central network with the north network the grid code has been unified. The authorities have also made it possible for project developers to simulate how future added electricity capacity will correspond with the rest of the grid which can be a substantial advantage for developers.

“They have everything posted in the network. It is really easy to work with them because they have their model in Dig-Silent and it is a public document you can download. In fact, they have the forecast of the new generation facilities included in this network and you will see how the network will perform in the future and you can perform some simulations in the future. If you want to know how your plant will perform three years in

the future, you can do that. This is an important point because you need to know if you will get some modification in the generation flow” (Participant 2).

Regarding the application for permits and achieving grid connection interview participant two did also express that this was relatively simple in the Chilean market:

“In Chile they have bureaucracy but it’s not a big.. It’s not a big deal if you were in since the beginning and doing the things as the law you will be able to get the connection without many issues” (Participant 2).

12.2 Infrastructure in Mexico:

The main governing bodies of the electricity market in Mexico are the Energy Ministry (SENER) which is responsible for the enforcement of energy policies. Comisión Reguladora de Energía (CRE) is the regulatory body and issue all electrical permits concerned with generation, distribution and transmission of electricity. The state-owned organization is also the biggest generator of electricity in Mexico through its subsidiaries. CENACE is the government body that manages the electrical grid and the wholesale electricity market.

The Mexican national electric system (Sistema Eléctrico Nacional or SEN) is one of the biggest in the western hemisphere. The country is divided into nine regions where eight is interconnected in the National Interconnected System (SIN). The Baja California region is interconnected with the western interconnection in the USA.

In Mexico several permits are needed in order to be allowed to build electricity generation plants. Generators need a permit for electric generation issued by CRE, federal environmental permits, permits from local and municipal authorities including local environmental permits, social impact studies issued by SENER, local civil protection programs, municipal land use authorization and municipal construction licenses (Serra & Escobedo, 2020).

For the electric generation permit a project description is needed comprising information about location, interconnection points, one-line diagrams, electricity generation capacity and information about the type of technology used for power generation. Supporting information regarding financial and technical capabilities of the company is also needed (Serra & Escobedo, 2020).

Concerning the connection to the transmission network the applicant must draft interconnection studies and attach technical information about the project published in CENACE templates.

The applicant must also pay for the interconnection studies, which can vary depending on location and local infrastructure (Serra & Escobedo, 2020).

The required authorizations needed in Mexico is not a lot different from the permits needed in other countries. However, as explained earlier corruption is prevalent in the process of obtaining those permits.

12.3 Infrastructure in Argentina:

The Argentine electrical grid (Sistema Argentino de Interconexión) is an interconnected electrical network that covers all of Argentina except from the southern province of Tierra del Fuego. The system does also have international links to Chile, Paraguay, Uruguay and Brazil. The electrical grid in Argentina has been criticized for being in bad condition with lacking upgrades of substations and cable connections (Henaio & Byrne, 2019).

The lack of reliability was illustrated in 2019 when Argentina together with Paraguay and Uruguay experienced an enormous blackout that left 48 million people without electricity for 12 hours. The failure happened when a 250km long transmission line between the Entre Rios province and Buenos Aires had been shut down due to repair. The transmission of electricity to the Eastern part of Argentina, Paraguay and Uruguay was secured through a temporary bypass in Buenos Aires. However, Transener that operated the by bypass line failed to secure that the DAG (Automatic Generation Disconnection) system worked properly. The fact that several generation companies pulled the plug to the system and deviated from the rules made things worse (St. James, 2019).

As mentioned earlier Argentina have clear ambitions to increase the country's supply of energy from renewable energy sources including solar PV, but the bad state of the electrical grid poses an obstacle to that strategy and to developers of solar PV plants. As the blackout in 2019 illustrated, large parts of the existing electric infrastructure in Argentina needs to be overhauled now in order to secure reliability with the current levels of transmitted electricity. Besides that, the country also needs to add new transmission lines and substations to secure transmission capacity for future added electricity generation. There are already several investment programs planned for the expansion of the transmission network in Argentina. This includes a 500kV transmission line between Buenos Aires and Mendoza that constitutes one of the best regions for solar PV exploitation due to the high levels of solar irradiation (KPMG, 2019, pp. 4–5).

In Argentina, power generation is not considered a public utility which means that fewer regulatory authorities are required for the construction of thermal and RE power plants. However, some of the permits needed to build plants includes environmental and health and safety authorizations, which are both needed on federal and local level. In order to connect the plant to the transmission network, the plant operator will need an authorization from CAMMESA. If there is not sufficient transmission capacity to cover the added power, an application to expand the transmission capacity must be made. This application is granted by CAMMESA and ENRE (Siboldi et al., 2020).

12.4 Infrastructure in Brazil:

The main regulatory authorities in the Brazilian electricity market are the Ministry of Mines and Energy (MME) with the responsibility of implementing national policies in the energy sector. Agência Nacional de Energia Elétrica (ANEEL) is an independent body linked to MME that regulate and monitor activities in the energy sector. Among several obligations ANEEL is the regulatory authority that organises energy auctions in Brazil. Operador Nacional do Sistema Eletrico (ONS) is the organisation that manages, operate and expand the National Interconnected System (SIN) (Schmidt et al., 2021).

The SIN system is comprised of four subsystems: South, Southeast/Midwest, Northeast and North. There are 212 locations in Brazil isolated from the SIN system of which most are in the North region in the states of Rondonia, Acre, Amazonas, Roraima, Amapá and Pará. The electricity supply in those areas comes primarily from diesel-powered generators. The SIN system has international links to Argentina, Paraguay and Uruguay (*ONS - Operador Nacional Do Sistema Elétrico*, n.d.).

The Construction permits needed to build Solar PV plants are granted by ANEEL. The requirements that developers need to fulfil are based on the technical, financial, and legal capacity of the applicant. Generators will also need three different environmental licences depending on the stage of the project – the previous licence, installation license and operating license. The requirements needed for operation of power plants is also issued by ANEEL (Schmidt et al., 2021).

One main obstacle for developers of solar PV plants is that the most favourable areas to exploit solar irradiation is situated far away from urban areas. That increases the cost of constructing plants and results in very high transmission and connection costs. However, the electrical

network in Brazil has been substantially expanded during the past years and Brazil is now home to the three longest transmission lines in the world including the Belo Monte-Rio de Janeiro line (2543km 800kV UHVDC line), the Rio Madeira transmission link (2365km 600kV HVDC line) and the Belo Monte-Estreito transmission line (2092km 800kV UHVDC line). This rapid expansion is partly driven by direct investments from Chinas State Grid Corporation (Power Technology, 2020). For solar PV developers the expansion and modernization of the grid brings further potential for exploitation of solar energy.

12.5 Assessment of variable:

In terms of electricity infrastructure all four countries share similar challenges related to their geography as they cover wide land surfaces. The fact that many of the optimum locations for solar exploitation are located far away from major cities and industries means that electricity has to be transmitted over long distances. While this challenge has been reduced in all four markets, the best progress seems to have been made in Brazil and Chile. The required licences and permits for electric generation are similar in all four countries but the simplicity and transparency of the processes differ. Chile and Brazil have been assessed as the easiest countries to operate within in this regard. The countries have received the following score on this variable:

Grid connectivity and technical barriers (weight: 17%)	
Chile	8
Brazil	6
Argentina	5
Mexico	4

13 Market selection

One the basis of the six variables Chile has been chosen as the more attractive market ahead of Brazil, Mexico and Argentina, in that order. In the following tables the scores for each country and variable can be seen in comparison with each other.

Chile				
Importance	Variables	Variable score	Country Grade	Country score

1	Barriers to FDI	22%	8	1.76
2	Exchange rate risk	21%	6	1.26
3	Renewable energy policy	20%	9	1.8
4	Grid connectivity and technical barriers	17%	8	1.36
5	Energy matrix	11%	8	0.88
6	Ad valorem tariffs	9%	10	0.9
		100%		7.96

Brazil				
Importance	Variables	Variable score	Country Grade	Country score
1	Barriers to FDI	22%	4	0.88
2	Exchange rate risk	21%	4	0.84
3	Renewable energy policy	20%	5	1
4	Grid connectivity and technical barriers	17%	6	1.02
5	Energy matrix	11%	5	0.55
6	Ad valorem tariffs	9%	5	0.45
		100%		4.74

Mexico				
Importance	Variables	Variable score	Country Grade	Country score
1	Barriers to FDI	22%	6	1.32
2	Exchange rate risk	21%	5	1.05
3	Renewable energy policy	20%	2	0.4
4	Grid connectivity and technical barriers	17%	4	0.68
5	Energy matrix	11%	4	0.44
6	Ad valorem tariffs	9%	8	0.72
		100%		4.61

Argentina				
Importance	Variables	Variable score	Country Grade	Country score
1	Barriers to FDI	22%	5	1.1
2	Exchange rate risk	21%	1	0.21
3	Renewable energy policy	20%	5	1
4	Grid connectivity and technical barriers	17%	5	0.85
5	Energy matrix	11%	5	0.55
6	Ad valorem tariffs	9%	4	0.36
		100%		4.07

Evaluation result

Importance	Variables	Variable score	Chile	Brazil	Mexico	Argentina
1	Barriers to FDI	22%	1.76	0.88	1.32	1.1
2	Exchange rate risk	21%	1.26	0.84	1.05	0.21
3	Renewable energy policy	20%	1.8	1	0.4	1
4	Grid connectivity and technical barriers	17%	1.36	1.02	0.68	0.85
5	Energy matrix	11%	0.88	0.55	0.44	0.55
6	Ad valorem tariffs	9%	0.9	0.45	0.72	0.36
Total		100%	7.96	4.74	4.61	4.07

14 Entering the Chilean PV market

It is assumed that most PV developers will pursue an international strategy that contains elements of the transnational strategy. Within this industry there is high potential for standardization within the erection of the power plants as many of the components used are more or less the same units across the world. The end product that the consumer receives is in this case electricity, which is a relative uniform good that requires no particular adaptation to local consumer tastes. However, since there is substantial local regulation attached to the construction of power plants including labour laws, environmental laws and technical requirements, PV developers will have to adapt to the local market conditions and can therefore not just follow a global strategy. Another aspect that supports the transnational approach and the need to respond to local market conditions is the cooperation with a wide variety of stakeholders including, local authorities, local communities, suppliers, subcontractors and clients.

In the preparation of the internationalisation strategy for new markets, PV developers can therefore benefit from studying the local industry and the main actors, cultural characteristics of the target market and advantages and challenges related to different entry modes. These aspects of the Chilean industry will be analysed and discussed in the following sections.

15 The industry based view

15.1 Industry rivalry

Competition within large scale solar PV development is primarily based on price, quality and time to completion with price being the most predominant factor (Berkeley Lab., n.d.).

At the end of 2020 there were 137 utility scale solar PV plants in Chile with a combined capacity of 3,229 GW (Wiki-solar.org, n.d.).

During the latest renewable energy auction in Chile that was held in September 2021, 29 companies submitted offers. The list of companies included large international MNCs like Acciona, Enel Greenpower, Sonnedix, FRV Development, Canadian Solar, Atlas energy, OPDE energy etc. There were also several Chilean companies that participated in the auction including Copiapó Energía Solar owned by Gasco, Llaima Energia and Arco energy (Ranjan, 2021).

Other major PV companies in the Chilean industry include TerraForm Power Inc, SunEdison Inc, Etrion Corporation, Mainstream Renewable Power, and Total Energies (Mordor Intelligence, 2021).

The density in the industry makes the competition for contracts fierce, which was also reflected in both attendance and prices during the latest auction round in Chile. The tender round which was a technology neutral auction held by The Chilean National Energy Commissions (CNE) resulted in the award of 2,310 GWh per year. Overall, the submitted bids totalled to 18,820 GWh per year. The auction prices averaged at US\$23.78/MWh. This is a price reduction of 27% compared to the previous major auction round in Chile during 2017 (Enerdata, 2021).

The lowest offer during the auction was submitted by Canadian Solar which offered a price of \$0.01332/kWh (\$13.32/mWh), which is not far from the world record of \$0.0104/kWh (\$10.40/mWh) that was set earlier during 2021 at an auction round in Saudi Arabia (Bellini, 2021).

The relative high number of both domestic and foreign-based solar PV developers and the low electricity prices compared to global prices point in the direction of a fragmented market where no companies have a dominant market position. The high number of market participants could bring one to the conclusion that the market is saturated and that it will be more attractive for new developers to look in the direction of other markets in LATAM with fewer industry players. This was also pointed out by interviewee 3, whose company had chosen to focus on markets in Brazil, Honduras and Argentina rather than Chile. Interviewee 1 and 2 on the other side remained very positive on the attractiveness of the Chilean market.

In the assessment of industry rivalry, it is important to remember that contract duration in this industry is long - typically lasting 15-25 years if developers choose to enter through PPA

agreements. The Porters five forces theory is typically applied to product industries where companies sell units measured in thousands or even millions. The solar PV industry deviates from traditional product industries in this regard as the signing of 2-3 PPA agreements could provide the PV developer with a long-term market presence in Chile.

It is also important to bear in mind that the potential projects that companies can participate in is not limited to the large auction rounds hosted by the government every 4-5 year. Besides these national auction rounds, there is a stable demand for PPA agreements in the “non-regulated consumer” segment put out to tenders by private companies and local utilities. This buyer group will be covered under bargaining power from buyers.

15.2 Threat of New Entrants

The entry barriers in the utility scale segment are very high because the industry is very capital extensive and requires substantial technical expertise. Furthermore the licenses, authorizations and permits that is needed to build PV plants acts as an entry barrier to new entrants as companies need to learn how to navigate the regulatory requirements even in a relative efficient market like the Chilean (Berkeley Lab., n.d.).

As covered in the previous section the high entry barriers have not stopped a high number of companies from entering the Chilean market. Some companies are ‘pure’ renewable energy developers that have emerged during the past years increasing demand for RE sources. Other companies are large energy corporations which used to operate in the oil and gas sector but which are now transitioning towards the use of RE sources. Both Italian based ENEL and French based Total Energies constitute examples of the latter.

15.2.1 Economies of scale as a competition parameter

In the assessment of new industry entrants, it is worth to consider scale economies as a competition element. One of the key drivers behind the intensive cost reductions that have happened in the global industry of solar PV generation is lower module costs. This has happened as a consequence of optimization of manufacturing processes, reduced labour costs and better module efficiency. Second, project developers have gained more experience and stronger supply chains have emerged in more markets (IRENA (B), 2021, p. 72). Some experts point to economies of scale effects as a key facilitator to the last years’ cost reductions and as an important future driver of expected declining solar PV prices (Olson & Bakken, n.d.).

As solar PV projects grow in size and numbers on a global scale it could allow the largest developers to reach better economies of scale effects measured over their project portfolios. An example of an area where very large developers could benefit from scale effects is the procurement of PV modules. The procurement of solar PV modules constitutes a substantial share of the total cost of building a Solar PV plant and if plant developers are able to place larger orders at the module manufacturers, they are also more likely to achieve higher bargaining power over these suppliers. This could ultimately result in lower procurement costs and improved competitiveness for the largest developers at the expense of smaller project developers with reduced global project portfolios.

A strengthening of economies of scale as a competition parameter could benefit larger companies who want to enter the solar PV industry - for instance large multinational energy corporations who see their traditional markets in decline. For one thing large capital strong organizations are more likely to overcome the initial entry barriers, while they can still benefit from existing knowhow connected to the cooperation with utility companies and grid operators. Second, large capital strong companies are more likely to have financial room for long-term strategic planning, which can enable them to gain long-term advantages. An example of this could be a large energy company which continuously decides to underbid market prices for a certain time period in order to win projects and build up a large project portfolio, which can enable them to gain economies of scale effects at the cost of profits for a number of years. Despite losses on initial projects this could help them gain long-term competitive advantages in procurement and construction phases.

15.3 Threat of Substitutes

As covered previously solar PV plant developers experience indirect competition from power plant generators based on fossil fuels, and also from other RE power plants such as wind, hydro and biomass. In order to assess the threat from substitutes and their competitiveness, it will be useful to apply the concept of Levelized cost of Energy (LCoE).

IRENA has studied the development in utility scale electricity prices from RE sources from 2010-2020. The report shows significant reductions in the LCOE of solar PV, concentrating solar power (CSP), off-shore wind and on-shore wind. In the meantime, there has been no reductions within hydropower, geothermal and biomass generation. Over the past decade solar PV generation represents the energy generation method with the highest LCoE reduction.

Between 2010-2020 the price of one kWh of solar PV energy has dropped from \$0.381/kWh to \$0.057/kWh. In comparison, on-shore wind dropped from \$0.089/kWh in 2010 to \$0.039/kWh in 2020 (IRENA (B), 2021, p. 15).

Despite the extensive reduction within solar PV generated electricity, on-shore wind and hydropower still remains slightly cheaper when the global average for each technology is compared. In addition, the pace of the LCoE reduction within solar PV generation is expected to take off a little bit. This trend is also visible in the latest year-on-year measurements from 2019 to 2020. Here the LCoE for new commissioned large scale solar PV plants dropped 7% while the equivalent numbers for off-shore wind was 9%, 13% for on-shore wind and 16% for CSP solar power (IRENA (B), 2021, p. 13).

The numbers suggest, that for the moment, there is no clear ‘winner’ among the RE technologies and therefore the competition from these substitutes will most likely be permanent for the coming years. In fact, with the introduction of technology-neutral auctions and tenders one could argue that wind developers constitute direct competitors to solar PV developers as they increasingly participate in the same auction rounds. The fact that several project developers are both engaged in wind and solar project development supports this view.

Still, it is worth mentioning that there are significant technologic differences between solar and wind development and, perhaps more importantly, that the specific geographical and climatic circumstances of a specific area will in many cases favour one technology over the other. This is also the case in Chile where the wind projects are typically found in the South and the solar projects in the North.

15.4 Bargaining Power of Suppliers

As mentioned previously some of the most important suppliers to PV developers are manufacturers of modules, inverters, racking and mounting, cables and wiring and HV equipment. Apart from the hardware suppliers, many developers choose to use local subcontractors for civil- mechanical- and electrical installation works rather than hiring local staff. The analysis of bargaining power from suppliers will primarily be based on PV module suppliers as this supplier group represents the largest individual component cost in most PV projects.

15.4.1 PV module suppliers

Most of the PV modules used globally are produced by Chinese companies in China. As mentioned, earlier the PV manufacturing industry is concentrated on relative few companies. Some experts point out that the past years' extreme upscaling, innovation and better performance combined with reduced prices in the PV module manufacturing industry have the potential of wiping out smaller manufacturers of modules. Another contributory cause to consolidation could be that several of the large Chinese manufacturers are state-owned companies and that the Chinese government might see an interest in supporting this industry. (Hall, 2020). A consolidation within the PV module industry would increase the supplier groups' bargaining power towards PV project developers and could ultimately reduce profit margins in some projects.

Another factor concerned with the procurement of modules are increases in commodity prices. This applies to silicon but also for aluminium used for the support structures and other metals such as copper. Silicon prices are not covered by analysts as widely as other commodities like aluminium or copper partly because it is not considered a scarce resource since it covers 28% of the earth's crust. However, during 2021 the global prices on Silicon increased more than 300% over two months. The price of one ton of silicon has typically ranged between 1,200-2,600 USD during the past decades. However during 2021 prices increased to 67,300 yuan per ton (10,588.25 USD) (Chia et al., 2021).

The explanation of the extreme increases in silicon prices can partly be explained by the COVID-19 pandemic. The processing of many metals includes a smelting process, which is extremely energy demanding. This is also the case for silicon. As noted, many of the world's biggest silicon processors are located in China. In China, the pandemic forced authorities to reduce production in coal-fired power plants which again resulted in a shortage on energy resources. Ultimately this forced authorities to introduce power curbs, which lead some silicon processors to reduce output or shut down production completely which have been a contributory cause to the price increases on silicon (Chia et al., 2021).

PV project developers typically do not participate in transactions with silicon producers as these companies are found further up in the supply chain. However, the price increases that module manufacturers are experiencing from their suppliers is likely to be passed on to their customers – the PV project developers in this case. While one could argue that the silicon price increase is an extreme event caused by a rare pandemic, it does show the fragility of the PV module supply chain, which is something PV developers should monitor closely.

Supply chain disorders related to electricity shortage and rising electricity prices are not only applicable to China. In Europe, rising electricity prices are squeezing producers of non-ferrous metals. This is for example evident in the aluminium smelting industry where electricity prices typically represent minimum 30% of total production cost. The increasing electricity prices in Europe have caused several European aluminium smelters to cut down production capacity or simply shut down production lines (Home, 2022).

In order to mitigate the risk of increased bargaining power from PV module suppliers, project developers in Chile and other places can take some steps to mitigate the risk of fluctuating prices. The fact that there are no tariffs and typically no LCR requirements means that PV developers have the freedom of being able to import modules from anywhere in the world. With a trend towards a more consolidated PV module industry with fluctuations in commodity prices developers could benefit from being less dependent on individual suppliers, even though a spread of suppliers might reduce the bulk discount.

15.5 Bargaining Power of Buyers

In the PV industry the bargaining power of buyers can be complicated to address in comparison with traditional products and services. First of all, the ‘product’ sold and bought depends on what kind of project developer the specific company is. Some project developers choose to sell the plant to another operator at the point of commissioning, thus delivering a turnkey project including design, engineering, and construction of a power plant, but not acting as an electricity seller. Other developers choose to act as electricity sellers by operating the plant themselves and by selling the electricity through fixed PPA agreements to off-takers. As the majority of companies seem to act as electricity sellers this is the sort of developer that will be analysed here.

In the Chilean PV market, there are two forms of consumers: regulated and unregulated. The unregulated consumers are large consumers that has an energy capacity of more than 2MW. These types of consumers are allowed to trade PPA agreements with generation companies on their own. The PPA structure allows the two parties to negotiate topics such as price, duration, indexation, and general conditions (Zurita et al., 2018, p. 708)

Regulated consumers with a power capacity of less than 500kW is subject to a regulated tariff set by Distributor Networks Operators (DNOs). The DNOs and the CNE put long term PPA

agreements out to tender with a structure of energy blocks where generators can offer their prices in certain time blocks (Zurita et al., 2018, pp. 708–709).

15.5.1 DNO tenders

The bargaining power of the buyer in these types of contractual arrangements is concentrated in the tender and auction period where the buyer chooses between the submitted offers and negotiate prices. It will be in the DNO's interest to attract as many bids as possible to secure high competition and lower electricity prices. One assumption could be that higher auction volumes equals higher interest from more auctions' participants. However, some evidence suggest that volumes can also get too high and thereby reduce the number of competitors that choose to submit offers.

The design of renewable energy auctions is an extremely wide topic, but the essence is that in the auction phase, the buyer has the privilege of dictating all requirements that the developer has to fulfil in order to be qualified for the project. After the commencement of the agreement the bargaining power is assumed to be lower since both parties will be very reliant on each other as there are substantial costs related to termination of an agreement. The bargaining power here will be very much governed by the contract specifications.

15.5.2 Non-regulated consumers

Non-regulated consumers will typically be large companies or organizations with a high electricity demand. In Chile, the mining industry constitutes one of the biggest industries in revenues and electricity consumption and is therefore of particular interest for solar PV developers (Behar et al., 2021).

The Atacama Desert is home to some of the highest solar irradiation levels in Chile and globally. The same area is also home to some of the biggest mines including the two biggest copper mines globally; The Escondida mine and the Collahuasi mine (Mining.com, 2021). The metals that are mined in this area are commodities that societies globally are going to demand in the future decades in order to succeed in the transition to a green economy. This includes copper, used in the conductor industry, and needed for capacity increases of electrical grids globally, lithium used in battery technologies for the car industry and storage of renewable energy sources and iron used for support structures etc. Many of the processes used in modern

mining are very electricity consuming. These processes include crushing and grinding and electro refining (Behar et al., 2021, pp. 1–3).

According to the Chilean Copper Commission's forecasts, the domestic electricity consumption alone in copper mining in 2028 will be 29.2TWh hours per year, but they also give estimates of up to 35TWh per years (Chilean Copper Commission, n.d., p. 1). This number is equivalent to Denmark's total electricity consumption in 2019 including households, industries and transport (Hinrichsen, 2020).

The local mining industry therefore constitutes a huge potential for PPA contracts with non-regulated consumers. It is evident that the mining industry is already looking at solar PV generation as a method to reduce operation costs and their carbon footprint. In 2019 the BHP mining company signed four renewable PPA agreements while at the same time accepting a 780 million USD penalty for the termination of their existing PPA agreement with a coal fired powerplant before time (Djunisic, 2019).

The bargaining power of this buyer group is quite similar to the DNO. Again, it is in the interest of the buyer to receive as many bids and offers as possible to secure low prices, while both parties have a high level of mutual dependence after the closing of an agreement.

16 The cultural context of the Chilean solar market

Development and construction of solar PV plants require cooperation with many different stakeholder groups including suppliers, local workforce, customers, local authorities, grid-operators and neighbouring communities, to name but a few. Managing these stakeholder groups can be challenging, but to do it in a foreign culture can prove to be even more difficult. Consequently, companies who want to enter the Chilean PV market can benefit from a better understanding of local culture as it might affect their strategic approach and entry mode. Delivering a thorough uncovering of Chilean culture including norms, values and basic assumptions would be too comprehensive for this thesis. However, Geert Hofstede's cultural dimensions will be applied in the following to give a brief account of the cultural characteristics that apply to the Chilean business culture.

16.1 Cultural dimensions of Chile

According to Hofstede's dimension, Chilean culture is characterized by having medium power-distance (63). Although this number is lower compared to many other Latin American countries, Chile still emphasizes clear hierarchies, tall organizational pyramids and foreigners should expect a relatively low degree of delegation. (Hofstede Insights, 2021) Considering decision making internally and with external resources, business practitioners should consider that having the right person with a high level of mandate, could be crucial in order to finalize decisions and settle agreements.

The low degree of individualism (23) means that people are more likely to have a “we-orientation” rather than an “I-orientation”. Belonging to a group is important and long-term relationships and loyalty is valued (Hofstede Insights, 2021). The relatively low score in masculinity (28) suggests that feminine values such as caring for others and quality of life are important values rather than competition and achievement. Most people in feminine cultures value warm interpersonal relationships and approval from others in the group. The management style is more often consensus building and people tend to solve conflicts through compromises and negotiation. Most employees are supportive team members who value free-time and flexibility in their work lives (Hofstede Insights, 2021). On the other side, it should also be mentioned, that managers and supervisors in Chilean workplaces are not expected to consult lower ranked employees. People expect that managers have been chosen because they have more experience (International Business Etiquette, n.d.).

Regarding uncertainty avoidance Chile has a very high score of 86. This means that society members attempt to avoid uncertainty. This is often done through establishing strict rules, laws, policies and institutions that aim to avoid uncertainty. The low tolerance towards unexpected events means that people have a tendency to be less risk averse and societal changes occur over longer time (Hofstede Insights, 2021). The long-term orientation in Chile is low to medium (31), which suggests that it is a normative society where people prefer to maintain tradition and norms. Members of the culture is more likely to focus on quick results than saving for the future. Chile is also an indulgent country rather than restraint (68). There is a tendency to value having fun and enjoying life, and people can act more impulsively compared to other cultures (International Business Etiquette, n.d.).

16.2 Chilean business environment

For a PV developer, Hofstede's dimensions can serve as a roadmap on how to manage relationships with suppliers and customers. One could argue that since the contract award is based on price, quality, and time delivery rather than relations the cultural part is of less importance here. However, the construction and operation of the plant will require close collaboration with the customer, so if relationships are not maintained this could create tensions which will complicate operations and ultimately lead to delays or increased construction costs. An example of this is evident from one of the interviewees previous experiences in the Brazilian market who found the cooperation with local utilities challenging. It should also be noted that customers in the non-regulated market is entitled to negotiate PPA agreement on their own and therefore they can evaluate tender offers from their own set of criteria which could bring further importance to relationships and reference projects.

Regarding the relationship with suppliers and subcontractors, adjusting to local culture will also prove important as many of the enterprises in this stakeholder group are likely to be domestic companies and SMEs. Regarding legal matters the usual practise in Chile is that changes and negotiations are not allowed after the signing of the contract (De La Cerda, 2018). This stands in contrast to some other cultures where the signing of the contract marks the beginning of negotiations or cultures where oral agreements are favoured. The low tolerance towards uncertainty and unexpected events means that developers could benefit from having a very thorough design, engineering, and project planning phase to reduce the amount of potential project alterations. While project changes should always be avoided, they can complicate things even more in environments where there is less room for changes to the contract and initial schedules.

Chile has a low level of corruption. In general, transparency is favoured in business and it is common to perform due diligence on business partners. Therefore intervention and local agreements should be avoided as they could be interpreted as corrupt (De La Cerda, 2018).

Finally, the local language Spanish should be considered. While many high ranked employees are bilingual, it is not necessarily the same for blue-collar workers. Communicating with external stakeholder through a second language like English increases the possibility of misunderstandings. Therefore, developers should consider hiring local managers rather than just opting for expat managers.

17 Entry mode strategy

As mentioned earlier, not all entry modes will be suitable for all types of companies. In the case of solar PV developers, the entry modes under the trading category are not viable options. While it is common that countries trade electricity with neighbouring countries this export and import of electricity is not carried out by private generation companies.

Under the contractual category, market entry through licensing and franchising agreements is unsuitable in the PV industry due to the intangibility of the products sold. Therefore, the discussion of entry mode will be concentrated on the different investment entry modes and management contracts and turnkey contracts under the contractual entry mode category.

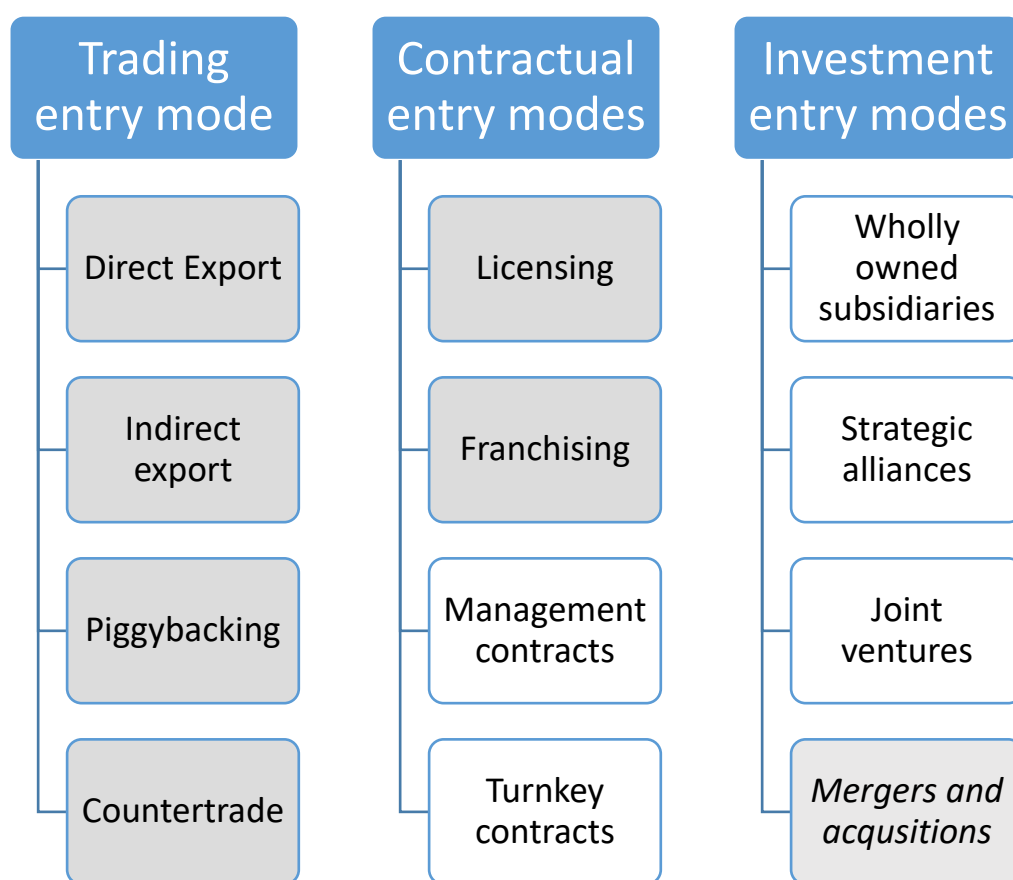


Figure 8: Different forms of entry modes (Author's own creation)

17.1 Discussion of contractual entry modes

Management contracts

Management contracts refers to an arrangement where a company supplies managerial expertise and knowledge within technical aspects and business management for a specific time

and receives payment in return. This arrangement is common in developing countries and also in the utility sector (Wild & Wild, 2020, p. 362).

In the case of a solar PV developer, a management contract could imply that the foreign PV developer signs a management contract in which the foreign PV developer agrees to operate a local plant which could be owned by a local utility or a capital fund that does not have the expertise to manage the facility on a daily basis.

Potential advantages of choosing the entry mode could be that the PV developers in this arrangement do not have to own assets in Chile. This entry mode requires less capital compared to other entry modes and the potential risk of financial losses is equally low. The entry mode constitutes an opportunity to enter the Chilean market in order to start harvesting tacit knowledge from the operation of the solar PV plant.

On the other side, it is worth mention that Chile is a well-developed country with a strong established industry for PV development. Therefore, companies that want to hire experts within this field are likely to find them locally rather than having to source management contracts from organizations abroad. Furthermore, a foreign company might be able to assist with the technical aspects of the operation of the plant but will have little or no knowledge about the location specific circumstances. As such, it might be more beneficial to hire local Chilean companies for management contracts, thus it is assumed that the possibility of entering the market through management contracts is very low.

Turnkey contracts

In turnkey contracts, the company awarded the contract agrees to design, construct, and test a facility for the customer – it is thereby the contractor’s obligation to prepare everything for the customer. At the point of commissioning, when the facility has to start operation, the client takes over the facility and “turns the key”. This entry mode is common in large-scale projects like infrastructure and clients are often government institutions. Turnkey contracts are also common within power plants and expansion of public utilities (Wild & Wild, 2020, pp. 362–363).

For solar PV developers the turnkey entry mode constitutes an interesting opportunity, as it can allow the company to gain experience with all aspects connected to the design and building of solar PV plants in the Chilean market. This implies permitting, design, construction, sourcing

of equipment and services etc. While this entry mode is also more capital intensive compared to the management contract mode and might require several years of commitment during the construction period, it is still less binding compared to entering through PPA agreements that can last several decades. The turnkey contract allows the PV developer to act as a construction company rather than as an electricity seller which is the case in the PPA agreements. The potential consequences of an unsuccessful turnkey project could be smaller compared to a 25-year long PPA agreement as risk towards some variables including exchange rate risk and RE policies are reduced. On the other side, the potential profit is lower, and the stable cash flow connected to an ongoing PPA agreement is not present in this arrangement.

17.2 Discussion of investment entry modes

Wholly owned subsidiaries

Under the investment entry mode, companies can choose to enter through wholly owned subsidiaries which are entirely owned by the parent company. In this entry mode, the company establishes itself in the new market by building new facilities (greenfield investment) or by acquiring existing facilities (brownfield investment). This mode of entry is capital demanding and is usually only used when the company is very committed to that specific market (Wild & Wild, 2020, p. 264).

Within the RE generation sector this entry mode is common. Since the development and operations of power plants are complex many developers choose to set up a local office through a wholly owned subsidiary in the target market. Some advantages connected to this entry mode is that the parent company is able to retain full control of the subsidiary. In this entry mode, there will be no need for coordination with strategic partners or joint venture partners. In addition, since a wholly owned subsidiary represents a great commitment in the foreign market, local managers might be able to build stronger ties in the local network including suppliers, clients, employees, and administrative authorities.

Strategic alliances

Strategic alliances are an entry mode where two or more organizations cooperate to achieve a common goal and thereby form a strategic alliance. Strategic alliances can take place with suppliers, buyers or competitors. This entry mode allows companies to combine their

individual skills and abilities to gain a competitive advantage (Wild & Wild, 2020, pp. 266–267).

In the case of the PV industry, a strategic alliance could consist of a PV developer and a PV module manufacturer that enter a strategic alliance. The PV developer pledge to excel within design, construction, and operation of PV plants in order to secure new PPA agreements. The PV module manufacturer on the other side secures access to high quality modules at an attractive price that can give the strategic alliance greater competitiveness in the auction round. The shared goal here is to achieve a market presence in Chile; for the PV developer in form of PPA agreements and greater electricity sales, and for the module manufacturers to sell modules to local projects through the PV developer's obligation to buy modules from this particular company.

The advantage of this arrangement is that it can give the alliance partners a competitive advantage as both companies contribute with their own respective skills. Further implications of the strategic alliance could be the design of modules that are particularly well-suited to the harsh environment, which is found many places in Chile including the Atacama Desert. In these areas, soiling, corrosion and degradation caused by local weather, as well as the mining industry, pose challenges to operators of PV plants as dust, soil, and acid mists affect the efficiency of the modules negatively (Haas et al., 2018, pp. 404–405).

Joint ventures

The joint venture arrangement has some similarities to the strategic alliance as it encompasses two or more companies joining forces to serve a specific market. However, in the joint venture arrangement the companies establish a separate company together and are therefore even more engaged in each other's activities compared to the strategic alliance. There are different configurations of joint ventures including forward integration, backward integration, buyback and multistage joint ventures (Wild & Wild, 2020, pp. 364–365).

The joint venture constitutes an interesting opportunity for foreign companies wanting to get a foothold in the Chilean PV market. One option could be the formation of a joint venture with a domestic company that has a better understanding of the local market characteristics and business operations in Chile.

While local PV developers might be reluctant to engage in joint ventures with foreign companies because they constitute a competitor entering ‘their’ domestic market, an alternative solution could be to form a joint venture with a local construction company. The formation of a joint venture with a local construction company would provide access to labour, machinery, local managers, and local supplier networks. On the other side, the PV developer could provide the expertise connected to entering PPA contracts, plant design, procurement of components and electrical engineering. Another benefit of the JV entry mode is that the financing of projects would be shared by two or more entities thereby reducing capital requirements and risk for both companies. There are of course also disadvantages connected to the JV option, hereunder the risk of conflict connected to decision-making, profit-sharing, loss of control and a reduced ability to adapt quickly to market changes. Another disadvantage of the JV entry mode is that it will require comprehensive research on finding the right company to venture with. In a fast-developing local PV market, this might result in a delayed entrance that will allow other companies to enter beforehand and let existing companies grow better economies of scale.

Interview participant 4 expressed that his company often engaged in partnerships with local companies before entering a new market. Regarding the company’s approach in LATAM he explains:

“So what we usually do in Ecuador, Colombia, Peru, Chile, where we don't have a presence, is that we do agreements with developers - so it could be like a joint venture or a co-development agreement where they bring the project all the way from development phase to ready to build. They are part of all the permits and licences, and we do our technical due diligence from our side and there is a premium developer cost that we usually have to pay. That's one of the most common ways of developing the project... We have these gate reviews that we need to pass with our top management and once we reach one of the gate reviews and we pass it, then we start establishing our own entity in the country that we want to set foot. We open an office, and we start hiring our team for asset management and finance and our O&M at a later stage.” (Interview participant 4)

18 Strategic recommendations:

The Porters five forces analysis shows that the existing industry rivalry in Chile is high with many domestic companies and MNCs battling for solar contracts. The analysis also shows that

the demand for added renewable energy capacity is very high and that solar PV power poses one of the most competitive energy sources in Chile. Despite the high number of market participants, there is no indication that the Chilean PV market is saturated at this point. This view is also supported by most of the interview participants who remain very positive regarding the Chilean PV market.

Both new market entrants and existing companies in the Chilean market should consider economies of scale as an increasingly important competition parameter. This might favour larger companies with large project portfolios.

The fact that the non-regulated consumers in Chile are free to negotiate PPA agreements with generators on their own, brings further possibilities for new PV developers as especially the widespread mining industry is very electricity consuming and can therefore benefit from reduced electricity prices from Solar PV powerplants.

The consolidation that is happening within the PV module manufacturing industry and further up in the supply chain is something that developers, not only in Chile but also in other markets, need to pay close attention to. Further industry consolidation among module manufacturers could affect the balance in bargaining power between module manufacturers and plant developers resulting in increased costs for the developer. Another issue related to the supply chain is volatile commodity prices on aluminium and silicon which can also affect the cost of component purchases.

Smaller companies might find it challenging to compete solely on price in the Chilean market. Those companies could attempt to differentiate themselves from bigger players by offering designs that have a longer lifetime cycles or better radiation efficiency. They could try to address some of the challenges related to the harsh environment, which is found many places in Chile, or by opting for innovative technologies that might be more expensive, but which have higher efficiency over time.

The cultural characteristics and business etiquette that are applicable in Chile should be considered when developers enter the market. The design and construction of the plants requires cooperation with a wide variety of stakeholders. Due to language barriers and a general high value of relationships and close ties, companies could benefit from hiring local managers rather than operating with expat managers. However, some of the interview participants did express challenges related to hiring qualified staff locally thus suggesting that the second-best option will be to hire staff from other locations in LATAM.

Concerning the different entry modes that PV developers can choose, wholly owned subsidiaries is probably the most prevalent entry form. Constructing and operating power plants is complex and requires a great level of engagement and local market knowledge about the target market. There are obvious advantages connected to the wholly owned subsidiary mode, especially the ability to maintain full control over business activities.

Alternative entry modes include the turnkey project which reduces the commitment that the developer will have to make in the new market. For companies that are not confident that they are going to stay in the Chilean market, this entry mode could provide a middle ground. The opportunity to gain access to the market through management contracts has been assessed as low, and is therefore not recommended.

Finally, entry through strategic alliances or joint ventures provide an opportunity to address some of the main challenges that have been identified in the Chilean market. The strategic alliance can be a viable option to overcome some of the challenges related to the solar supply chain. In this form, the PV developer could collaborate with a module manufacturer with limited or no presence in the Chilean market. In this entry form, both companies could benefit from a shared interest in establishing a local market presence. Besides that, the strategic alliance offers possibilities to develop solutions better suited for local conditions including environment, weather and climate.

The JV entry mode provides the possibility of achieving market presence in Chile with a shared financial risk and, perhaps more importantly, with a better chance of addressing the challenges related to attracting qualified labour, overcoming the cultural differences, and gaining access to local supplier networks. The formation of JVs with local construction companies could provide an easier path to tackle the challenges related to building in a new market as the local companies are more likely to have a better understanding of local construction regulation and practices. As several interview participants expressed, struggles related to hiring local labour in some of the most attractive areas for solar PV development are common, so the joint venture form is also a viable option in this regard, as local companies are more likely to have a better connection to the local labour market and supplier networks.

19 Conclusion

This thesis has covered the main variables that developers of large-scale PV power plants must consider during operations in LATAM. The research and analysis suggest that based on market size and solar irradiance, Argentina, Brazil, Chile and Mexico constitute the biggest markets with the highest potential for PV developers in this region of the world. Through examination of industry reports, academic articles, and interviews with industry practitioners in LATAM, the thesis provides a thorough understanding of the industry characteristics, and the variables that shape PV companies business opportunities.

The following six areas have been identified as crucial variables within the industry: Barriers to FDI, Exchange rate risk, Renewable energy policies, Ad-valorem tariffs, Grid connectivity and technical barriers and the present Energy matrix in the respective countries. Through a comprehensive analysis of the four countries on the identified variables, Chile has been identified as the most attractive market for foreign PV developers in front of Brazil, Mexico and Argentina, respectively. The Chilean market is distinguished by ambitious renewable energy policies that force utilities and distribution companies to invest in renewable electricity generation. Other contributory factors include the absence of LCR requirements, low barriers to FDI and relatively easy and transparent procedures related to obtaining permits and licenses for the construction of solar PV plants. Finally, the fact that there are no major tariffs applied to the importation of materials and components is another relevant aspect.

In the second part of the thesis, the Chilean PV sector has been analysed further. The findings suggest that the internal competition within the industry is intense with many local and multinational companies participating in the development of PV power plants. Despite this, the market remains attractive for new-comers due to the vast number of public electricity auctions and private companies' demand for PPA agreements, in particular within the high electricity consuming mining industry, which is dominant across Chile.

Finally, turning to different forms of market entry modes, the third part of the thesis, analysed and discussed the most attractive entry modes for foreign companies in relation to the Chilean market. This discussion shows that potential new market entrants could in some cases benefit from alternatives to the more commonly applied wholly-owned subsidiary, and in some cases from strategic alliance arrangements or joint ventures instead. Some competitive advantages to be obtained from this include lower module cost, improved efficiency, and better access to local labour force. Potential turnkey contracts offer another alternative in which developers can

obtain tacit knowledge connected to building in Chile, but without the decade long commitment that typically follows entering into PPA agreements.

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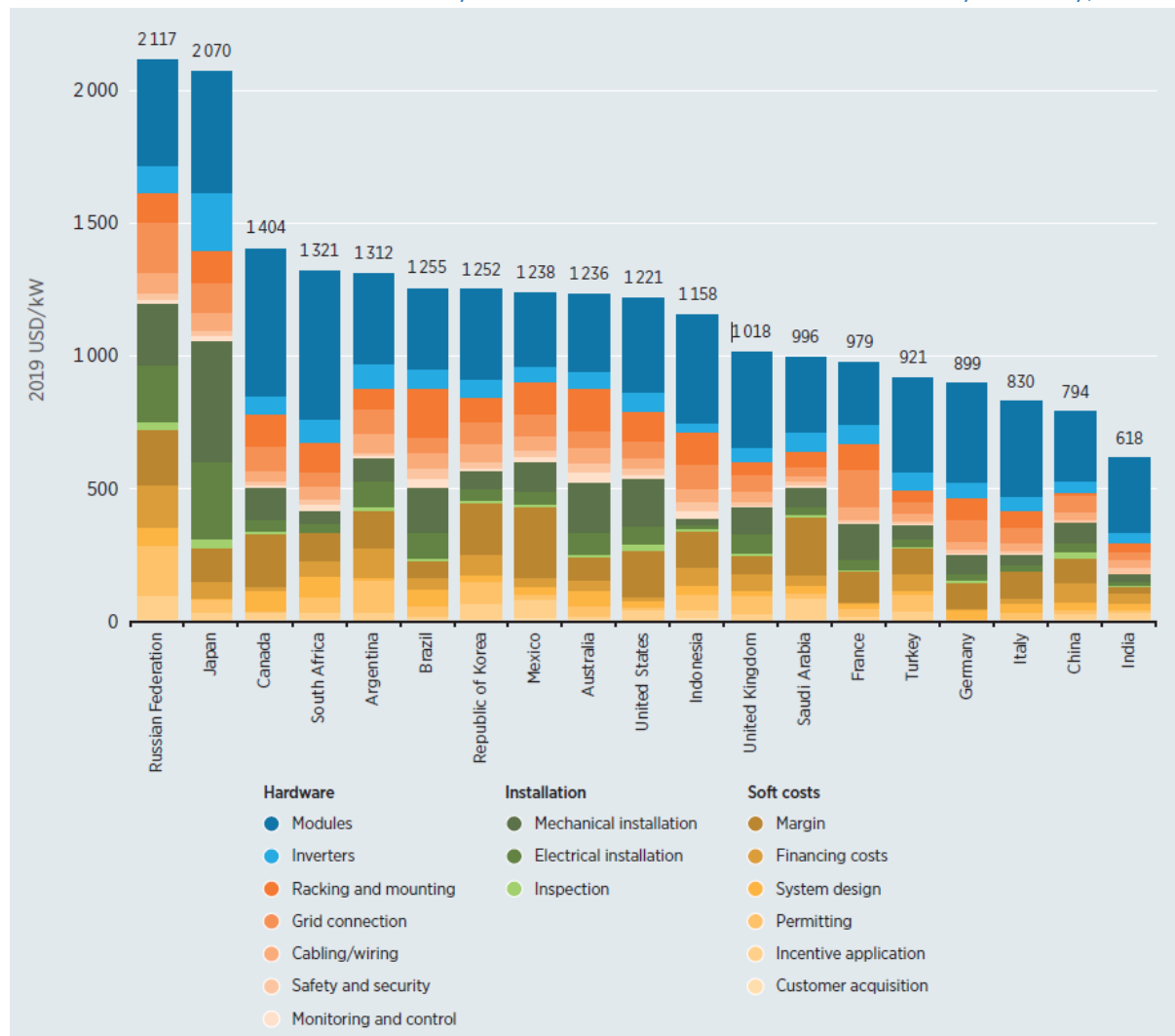
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Graphics:

Front page: <https://www.istockphoto.com/photos/solar-farm-sunset>

20. Appendices

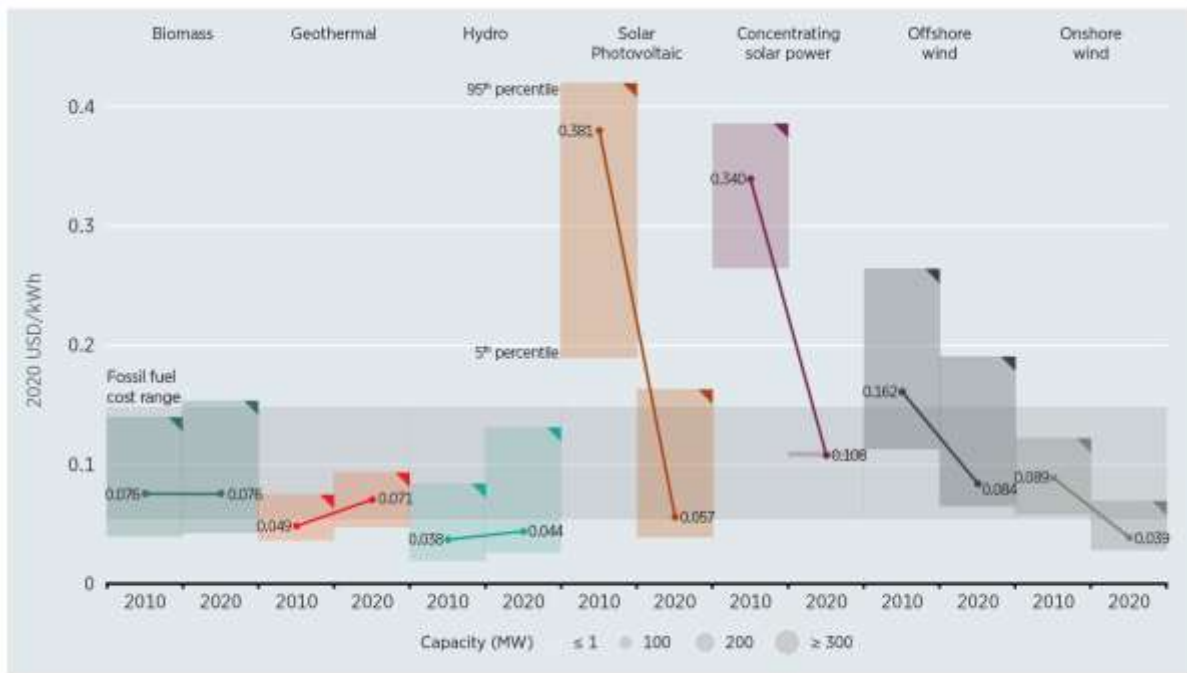
20.1 Detailed breakdown of utility-scale solar PV total installed costs by country, 2019



1

¹ https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jun/IRENA_Power_Generation_Costs_2019.pdf

20.2 Global LCOEs from newly commissioned, utility-scale renewable power generation technologies, 2010-2020



2

² <https://www.irena.org/publications/2021/Jun/Renewable-Power-Costs-in-2020>